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ARBORETUM BULLETIN

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Concerning this issue...

Our continuing efforts to bring readers of the *Bulletin* an interesting mix of subject matter has once more been achieved, we feel, although the necessity of printing the annual index in our spring issue cuts down the number and length of articles we can publish.

The Arboretum is a busy place this spring. Not only are the Flower Show, Work and Fun Day and the Arboretum Foundation Plant Sale the targets of much Unit Council activity, but a new program has been launched—a Horticultural Af-Fair for high school students. Most important of all, the environmental impact statement for the Master Plan Update, Washington Park Arboretum, is under review, and a search is underway for a new Arboretum director. All these are covered in the present issue.

Plant nomenclature is and has been a continuing problem for readers, authors and editors alike. Many gardeners instinctively dislike the use of Latin names. But the problem does not stop with the choice between common and botanical names. The number of changes in botanical nomenclature in recent years has been overwhelming. Brian Mulligan called attention in the previous issue (41:4) to the *Leucothoë* mess; this writer has lived through at least one other change from *Leucothoë catesbaei*, as have so many others of us. Frank Doleshy's article on the revision of the genus *Rhododendron* is a prophecy of more changes to come. Sue Olsen's article on ferns quite frankly follows horticultural rather than botanical nomenclature.

Whenever possible, the *Bulletin* has used new names with some indication of earlier synonyms (cf. *Fothergilla major* [*monticola*] in Mrs. Miller's articles), but we feel that further clarification would be helpful. For this reason in the near future we hope to publish yet another article on nomenclature. There have been others in the past, and these will be cited at that time.

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ARBORETUM BULLETIN

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COVER
Seattle Freeway Park—
cascades and concrete.
(See article, page 22)
Photo: G. Pirzio-Biroli

Mimicry in Plants

*ROGER DEL MORAL**

My interest in plant mimicry was piqued while exploring the bush around Beechworth, Victoria, where mistletoes and Eucalpytus *abound. This paper was improved by the suggestions of my colleague, B.J.D. Meeuse.*

Things are rarely as they seem. This statement is true in the everyday world of human interactions and it is also true in the natural world. Deception is a powerful weapon in the arsenal of self-preservation, and many plants, like animals, elevate deception to a fine art. Mimicry is a form of deception in which the outward appearance, and often also the smell and the behavior, of one organism (the mimic) is molded by agents of natural selection so as to produce a strong resemblance to another organism (the model). The mimic gains some form of advantage by its resemblance to the other, often quite unrelated, organism.

In this paper I will explore the various forms of mimicry practiced by plants. What are the selective agents involved? How does the mimic gain advantage? What are the limitations of mimetic systems?

The most intensively studied cases of mimicry involve butterflies. Because many of the principles of mimicry are illustrated by the case of "Batesian" mimicry,** I will describe it briefly before turning to plants.

Tasty butterflies often evolve an uncanny resemblance to specific distasteful butterflies. A famous North American example is that of the model/mimic pair formed by monarch and viceroy. Like many other models, the monarch "advertises" its unpleasantness by a striking, easily remembered color pattern. Butterfly predators are usually birds that must learn what tastes good and what doesn't. They rapidly memorize the color pattern associated with "bad taste." By being visually indistinguishable from a distasteful butterfly, a tasty one is thus likely to be passed over by an experienced predator. There are limits to this system. If the mimic becomes too common, predator learning becomes confused. One butterfly is distasteful, but the next tastes good. The predator fails to learn its lesson and, if sufficiently hungry, may continue to attack the morph (i.e., all individuals possessing the particular color pattern). Thus both mimic and model lose the protection afforded by advertising bad taste. Elevated predation on the model results in the model's "evolving away" from the mimic. In any population there is a range of morphological patterns. Models least like the mimic are most likely to retain protection by virtue of their pattern and on average these will produce more offspring. Hence there is a continuous evolutionary chase. As the mimic approaches a model in color pattern, pressures intensify to drive the model away from that pattern.

Mimicry in plants is equally interesting. I will describe several types in the sections that follow.

Types of Mimicry in Plants

In Table 1, I have listed several potential types of mimicry, involving plants as the mimic. Cases in which the plant or a portion of a plant serves as the model for an animal are not considered.

Without doubt the most renowned case of plant mimicry involves certain species of *Ophrys,* a genus of terrestrial orchids. Linnaeus, and later Darwin, noted that the flowers of *O. insectifera* resembled "flies." However, it was not until 1916 that Pouyanne provided convincing proof that flowers of the Mediterranean mirror-orchid, *O. speculum,* which show a striking resemblance (both in visual appearance and smell) to females of certain *Scoliid* wasps, are regularly visited by male Scoliids who attempt to copulate with the flowers. The structure of these flowers is such that

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*Roger del Moral's sabbatical in Australia in 1976-77 has inspired a number of fascinating articles for the *Bulletin*: two on the botanical gardens at Canberra (40:2, 1977) and Melbourne (41:3, 1978), as well as a discussion of the biogeography of the genus *Nothofagus* (41:1, 1978). The many-faceted subject of plant mimicry is well suited to his field of specialization, ecology. He is Associate Professor of Botany at the University of Washington.

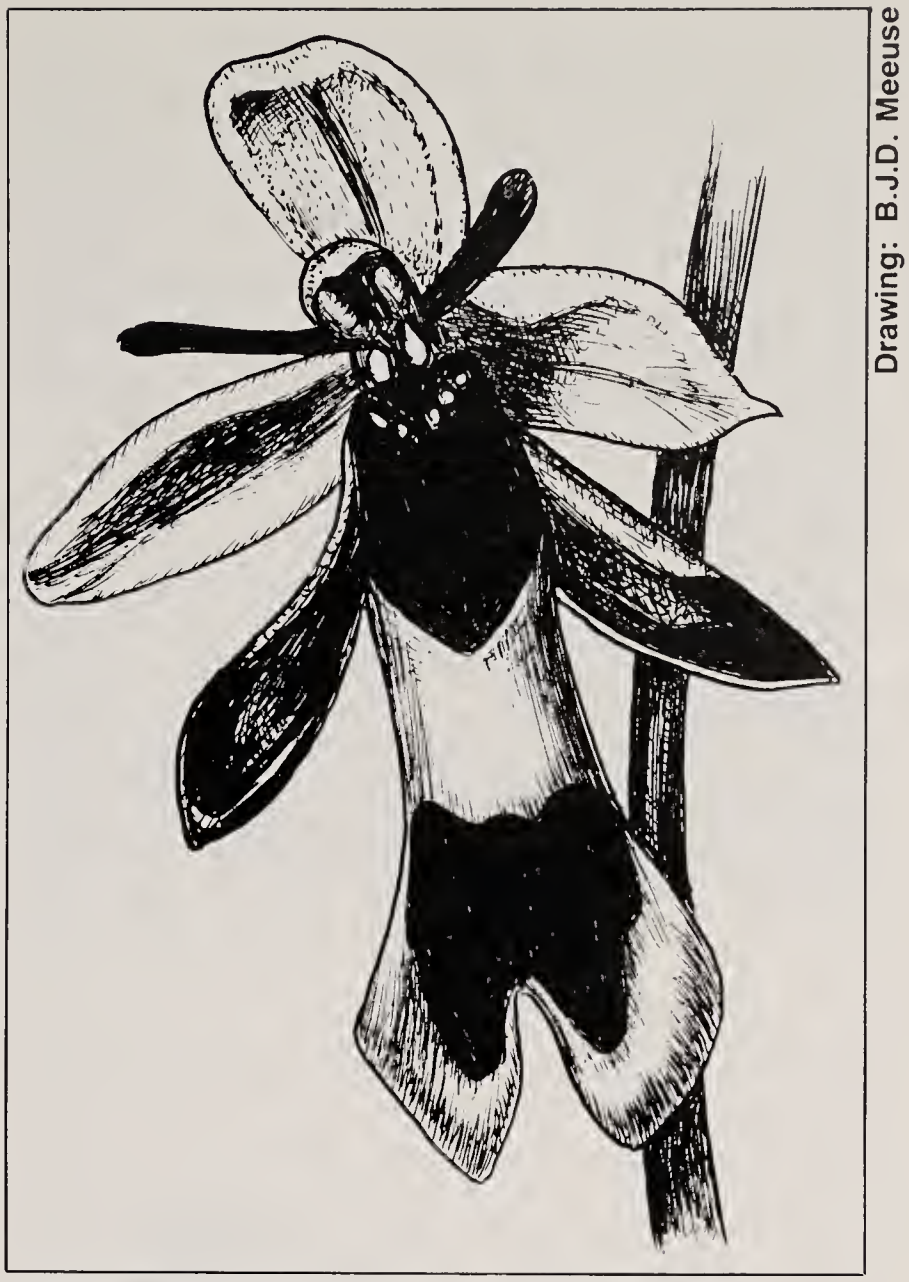
**Named after H.W. Bates who, in 1862, advanced the hypothesis that false warning coloration would confer a degree of protection on those organisms which evolved it.

their pollinia (pollen masses) become attached to the insect. A subsequent copulation attempt with another mirror-orchid flower usually results in pollen transfer and seed formation. This mimicry system is highly specialized in the sense that only one or a few species of wasps or bees will attempt to copulate with a particular orchid species. The deception extends to specific sex-attractants (pheromones) produced by the flower.

Passive movement by orchid flowers, caused by a slight breeze, plays a role in pollination of South American Oncidiums whose flowers are "rammed" by the males of *Centris* bees defending their territory. Movement, combined with the orchid's resemblance to *Centris* males, is adequate to provoke repeated attacks by *Centris* males, resulting in transfer of pollinia.

An important factor in pollination systems of this type is the behavioral rigidity of the pollinator; the ramming reaction of the *Centris* males is instinctive and not subject to modification by learning. The males continue to charge like wild bulls and remain effective pollinators.

In general, pollinators are lured by odor, color, shape or combinations of these attractants, while they receive a reward in the form of nectar or pollen. However, as we now know in this Age of Ecology, "There ain't no such thing as a free lunch." All actions exact a price. While pollination may be ensured by the provision of a nectar reward, many species evolved mimetic systems to provide less than is advertised. Thus, the flowers of *Parnassia palustris* and *P. fimbriata* have in their flowers conspicuous false nectaries promising an insect Nirvana (for an illustration, see "Bribes, decoys and ant guards" by B.J.D. Meeuse in the *Arboretum Bulletin* 1977, Vol. 40, No. 4, p. 30). Although the pseudonectaries are nearly devoid of nectar, the attraction works, at least for flies. Presumably, the energy costs associated with maintaining false nectaries are more than compensated for by the reduction of nectar production.



Drawing: B.J.D. Meeuse

Fig. 1. Flower of the fly orchid, *Ophrys insectifera*.

Other plants, particularly those in the skunk cabbage and milkweed families, imitate another energy resource. For example, the South African starfish flowers (*Stapelia* species, of the milkweed family) may both look and smell like decaying flesh. They attract female flies very effectively, who are deceived to such an extent that they will deposit their eggs in the flowers (fig. 4). The plant benefits because the ovipositing insects may well achieve pollination. However, the maggots perish since they find no adequate food. In a sense *Stapelia* is parasitic on the flies involved because it prevents its benefactors from leaving descendants.

The mousetail plant, *Arisarum proboscideum,* of the arum lily family, mimics mushrooms. The cylindrical floral chamber is completely closed, except for a window that faces earthward; female mushroom gnats gain access through it to the so-called appendix of the inflorescence which is light-colored and spongy, reminiscent of the tissue on the porous underside of a *Boletus* mushroom's cap (fig. 3). Its smell also has been re-

Table 1. Types of morphological mimicry in plants.

Mimic	Model	Example
Flower	Insect, female	Pseudocopulation in orchids
Flower	Insect, male	Aggression from bees in *Oncidium*
Flower	Rotting meat	Flies attracted to *Stapelia*
Leaf	Flower	Insect traps in *Drosera* and *Dionaea*
Seed	Seed	Wheat mimics rye
Fungus	Seed	*Clavipes purpurea* conidia on rye plants
Leaf	Leaf	False flax mimics true flax
Plant	Leaf	Mistletoes mimic *Eucalyptus* leaves

Fig. 2.
The mousetail plant and a detail of its inflorescence.
Drawing:
B.J.D. Meeuse

Fig. 3. The mousetail plant as it appears in nature.

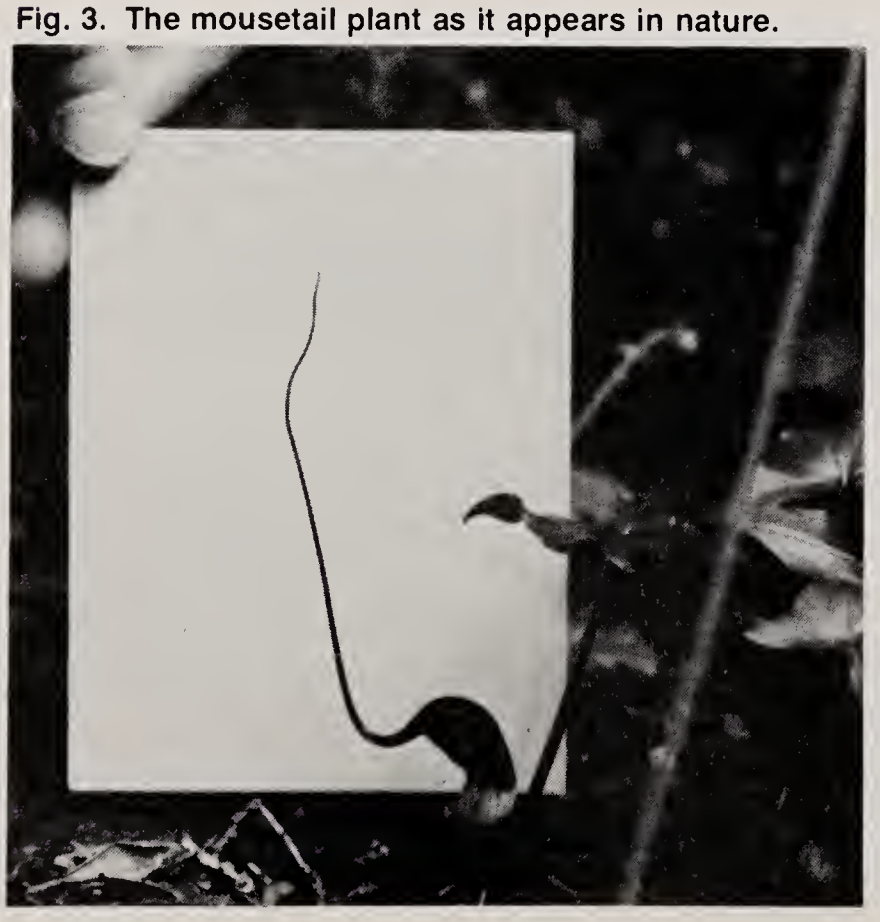


Photo: B.J.D. Meeuse

ported to be "mushroomy." So deceived, the gnats deposit their eggs in the pores of the appendix. At least some penetrate into the floral chamber where they will pollinate. Stefan Vogel confirmed Arcangeli's original report on this phenomenon and has reported similar situations in a Japanese ladyslipper orchid, a Mexican species of *Aristolochia* (Dutchman's pipe) and some species of *Asarum* (wild ginger).

An even more "wicked" case involves some insectivorous plants. The leaves of sundew (*Drosera* spp.) and Venus fly-trap *(Dionaea muscipula)* are thought by some investigators to mimic flowers. An over-inquisitive insect lands, looking for a nectar or pollen snack, but, instead it becomes dinner. The leaf-bases of several pitcher-plants (for example, *Nepenthes, Darlingtonia,* and *Sarracenia*) form tubes that may mimic blossoms and which secrete digestive enzymes into their cavities. Insectivorous plants are virtually restricted to bogs where nitrogen is scarcely available, so that the insect protein may be indispensable.

Of a more recent origin is mimicry of crop plants by weeds. This mimicry takes several forms, unified by the selective agency of humans. The earliest crops became crops by virtue of their ability to grow rapidly in disturbed, nutrient-rich habitats such as midden heaps. Such crops include wheat, millet, corn, flax, soybeans and cotton. Anthropologists now believe that while our male ancestors were out hunting game, our female ancestors began to select for favorable traits among the plants associated with the village. Large size of the edible portion was the major trait. Since it was realized from the beginning that plants grow better without competitors (weeds), humans practiced selective predation against competitors at the inception of agriculture. Weeds, ecologically, are similar to the earliest crop plants in that they have high growth rates, produce many seeds, respond to nutrients and are usually annuals. For a human predator to remove the weed, it must first be recognized. Thus, there is strong "unconscious" selection for a weed to mimic its crop. If 99 percent of the weeds are removed, the remaining 1 percent will, on average, be comprised of those individuals most difficult to distinguish from the crop. Over the generations, such unconscious selection has molded many species of weeds.

Camelina sativa linicola (false flax, a crucifer)

has a thin unbranched stem and pale leaves; it resembles *Linum usitatissimum* (flax) closely. The mimicry extends to seeds. Unlike its wild congeners, seeds of *C. sativa* are not dispersed except by the winnowing practiced in the cultivation of flax. In this way, seeds of *Camelina* remain unseparated from those of *Linum*. Not only is *Camelina* a flax mimic, it has become dependent on agriculture for its existence.

Some mimics adopt the role of crops so completely that they have, indeed, become crops. The prime example is rye *(Secale),* originally a weed of wheat. Selection for larger wheat seeds led to unconscious selection for larger rye seeds. One day, an ancient savant regarded the rye-infested wheat field and thought, "Why bother weeding out rye when I can grow it for food? It's obviously adapted to this climate and soil and I bet I can get a super price for this exotic item at the bazaar." (This is obviously a very loose translation of the Mesopotamian peasant's thoughts.)

Higher plants are not the only seed mimics. The sclerotia (overwintering stages) of *Claviceps purpurea,* an ascomycete fungus, are black and are very similar to healthy cereal grains; in fact they are scarcely distinguishable from rye grains and are often incorporated into the seed stock, thus reinfesting the next rye crop. Unfortunately, the sclerotia are also often incorporated into the bread. They contain LSD and several other toxic compounds, and may lead to ergot poisoning, also known as St. Anthony's fire. During the Middle Ages, thousands perished from this disease. Ergot destroyed the cavalry of Peter the Great in 1722, shortly before his invasion of Turkey. Of such things history is made. It is now believed that some instances of "witch-like" behavior in Salem were due to hallucinogenic side-effects of ergot poisoning.

Agents of selection mentioned thus far have been invertebrates or humans. Yet it is unreasonable to expect the list to be so short. Indeed, a recent paper by Barlow and Wiens (1977) suggests that the remarkable convergence of Australian mistletoes to resemble several genera of woody trees is mimicry that results from predation by certain marsupials.

In leaf-leaf mimicry, as in other forms, artistry is more important than architecture. That is, mimetic convergence need only be "skin-deep" — sufficient to give the appearance of similarity without the mimic's undergoing significant internal

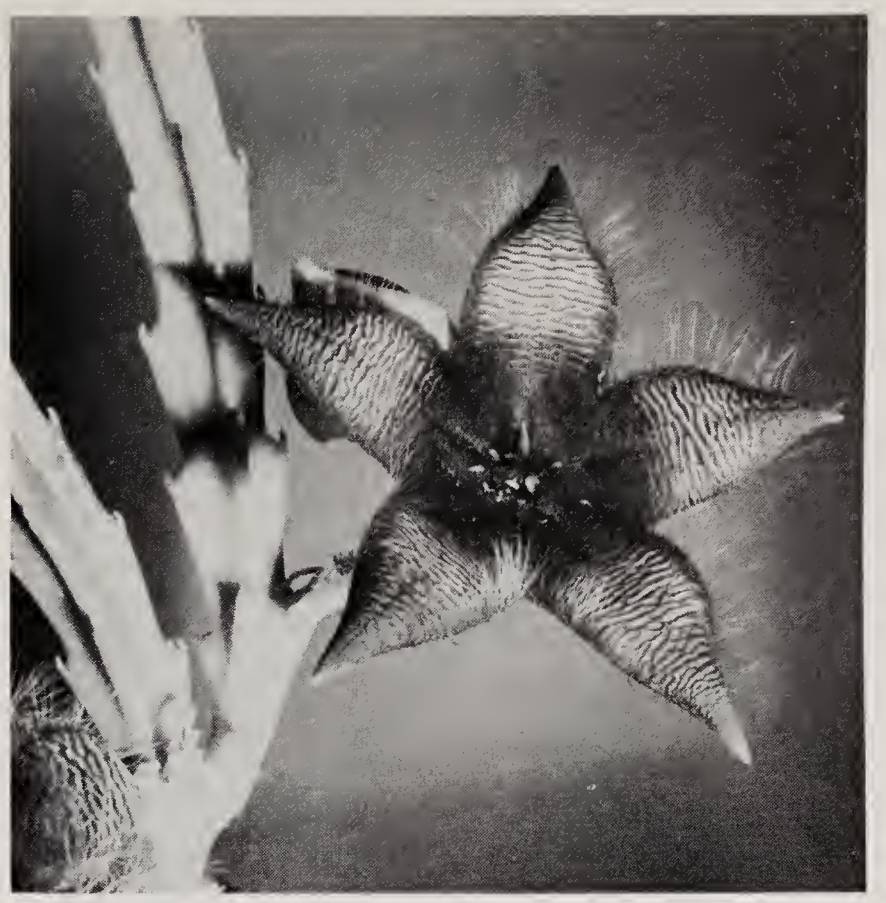


Fig. 4. *Stapelia* flower with fly eggs in the center (see page 3). Photo: B.J.D. Meeuse

changes. Most host-specific mistletoes that appear to be mimics occur in open woodlands and savannahs. These species are specific to one genus and sometimes to a single species. Some examples are provided in Table 2. Figure 5 provides a glimpse of this pattern. The leaves of *Amyema miquelii* are intermingled with those of *Eucalyptus bridgesiana* but the flowers are distinctly different. Of the 64 species of Australian Loranthaceae in 11 genera, 20 are considered to have high host specificity and 17 have a wide host range but closely resemble the foliage of a predominant host. Amongst the genera serving as models for restricted species are *Eucalyptus, Casuarina, Hakea, Grevillea, Acacia, Avicennia, Rhizophora, Flindersia, Callitris* and *Melaleuca*. All of these genera are widely distributed in Australia, though relatively few of the species suffer mimetic parasitism. The leaf forms of these gen-

Table 2. Some examples of Australian Loranthaceae that are highly specific for their host and are strong mimics.

Mimic	Usual host
Amyema bifurcatum	*Eucalyptus* spp.
A. cambagei	*Casuarina* spp.
A. gibberulum	*Hakea lorea; Grevillea nematophylla*
A. hillianum	*Acacia estrophiolata*
A. linophyllum	*Casuarina cristata*
A. lucasii	*Flindersia maculosa*
A. mackayense	*Avicennia marina; Rhizophora* spp.
A. miquelii	*Eucalyptus* spp.
Dendrophthoe pelagica	*Rhizophora* spp.
Diplatia furcata	*Melaleuca* spp.
Muelleriana bidwilli	*Callitris* spp.

Photo: Roger del Moral

Fig. 5. Mistletoe mimics *Eucalyptus* (see cover, *Arboretum Bulletin,* 41:3, 1948 for similar *Eucalyptus* leaves).

era are quite variable. *Eucalyptus* has typically long, narrow, often falcate leaves. Acacias that are mimicked are of the type which has phyllodes (see article by the author in the *Arboretum Bulletin,* Vol. 40, No. 2, p. 18). *Casaurina* has linear, terete leaves reminiscent of pine needles. *Callitris,* a conifer, has scales like those of *Juniperus*. And *Rhizophora* and *Avicennia* are mangroves with thick, orbicular leaves. The degree to which the mistletoes blend in with their respective hosts is punctuated when there is an inappropriate match. For example, the bizarre *Casuarina* I encountered in central Victoria was actually suffering parasitism from a eucalyptoid *Amyema* species.

The case for mimicry in this instance depends on a number of observations. The mimic must obtain advantage by resembling the model. Barlow and Wiens summarize their evidence as follows: 1) leaf forms in Loranthaceae are not correlated significantly with the general environment. 2) The genetic basis of this morphology is inferred from the fact that species such as *Lysiona exocarpi* and *Amyema miquelii* show little variation when found in inappropriate hosts. 3) Several lines of evidence demonstrate that leaf form is not controlled by the uptake of host hormones. The simplest hypothesis to explain the phenomenon of leaf-leaf mimicry is that natural selection has acted, in several different groups, to mold the leaf morphology of mistletoes. What is the selective agent?

Mistletoes may "parasitize" the host's vectors for pollination or fruit dispersal, but this is unlikely for several reasons. Mistletoe flowers are quite different from the host and are quite specialized. Flowering-time rarely coincides with that of the host. Pollinators are not attracted by vegetative similarity; rather they cue in on floral signals. Mistletoe fruits are brightly colored and their seeds are dispersed efficiently by birds, usually in no way connected with the dispersal of the host's seeds.

Far more likely is that mimicry serves to enhance concealment from herbivores. Insects are quite successful in using mistletoe leaves and employ non-visual cues. Mistletoes are quite palatable to cattle and camels in Australia. Of the native Australian marsupial fauna, many may be dismissed. Kangaroos and wallabies are terrestrial grazers (the tree kangaroo is an exception confined to the tropical rainforest) and therefore inappropriate selective agents. The koala is specialized on *Eucalyptus* and does not eat mistletoe. Possums and gliders (marsupial squirrels and flying squirrels) feed on foliage of various kinds. The ringtails and brush-tailed possums eat mistletoes and the latter is widely distributed in Australia. Possums are nocturnal, have excellent vision and appear to cue in on leaf shape. They dislike *Eucalyptus* leaves. Anecdotal evidence abounds, but the most significant is that during the last 40 years, possum populations have suffered near extermination in many places, while mistletoe populations have exploded to epidemic proportions in the same areas. Possums introduced to New Zealand are reported to cause dramatic reductions in mistletoe populations. The evidence suggests that Australian mistletoes are a rare case in which leaves of one plant mimic leaves of another to gain protection from its herbivores.

Conclusions

Mimicry in plants results from strong forces of natural selection. The forces may result from seed predation (false flax), herbivory (mistletoes),

competition for pollinators or dispersal agents (several orchids) or from nutritional problems (insectivorous plants living in bogs). Mimicry may be morphological, chemical, behavioral or a combination of these. As with all else in natural selection, there appear to be trade-offs, or countermoves, involved in mimetic systems. Mistletoes cannot become so successful that they kill all their hosts. Similarly, false flax cannot become so common that the flax field is abandoned. In general, there is selection in parasitism that moderates the parasitic effects. Parasites that kill their host rapidly leave fewer offspring than those that prolong the infestation.

The study of trade-offs is one of the most exciting areas of that exciting science, ecology. What factors result in a balance of traits and which determine how much effort can be devoted to various functions are being studied extensively. In mimicry studies, the operational forces resulting in a dynamic balance between model and mimic are sometimes obscure. Certain systems which we see operating beautifully around us, could not possibly have developed. However, recalling Ehrlich's rule, "what, given the original observations, exists is possible," leads us to further observations and more incisive, critical studies. The sophistication found in certain natural situations usually turns out to be even better than was held possible initially. What keeps all wasps from copulating only with orchids? Such behavior would quickly lead to the extinction of both the pollinating insect species and the orchid. Two answers are convincing. First there is likely variation in the frequency with which male wasps are deceived into pseudocopulation. Granting that there is a genetic basis for recognition by male wasps of their female counterparts, then there is a corresponding range of genetic types among the males. Selection, therefore, acts so as to cull out the gullible individuals. Males less gullible stand a better chance of leaving offspring than those fooled early and often. But in the long run this would lead to the creation of a wasp population in which few males would be inclined to indulge in pseudocopulation; the chances of the orchid to be pollinated would be severely curtailed, and if it has no other means of reproduction, it would, as a result, probably die out. So, this line of reasoning reemphasizes that the orchid cannot be both a good mimic and a common plant. But what do we find in reality? Generally mimetic orchids are rare, but in Spain mirror orchids are quite common and nearly perfect mimics. They must attract many male wasps, and if they essentially prevented these wasps from having many offspring, how could the situation possibly be maintained? The paradox is resolved when it is realized that males appear several days before their females; they are quite randy and all try to mate with *Ophrys*. However, once their females appear they mate preferentially with those, leaving enough offspring of the "right" genetic type. It is such subtle and awe-inspiring modulation of the interactions between and among different organisms that make the study of ecology so worthwhile, challenging and exciting.

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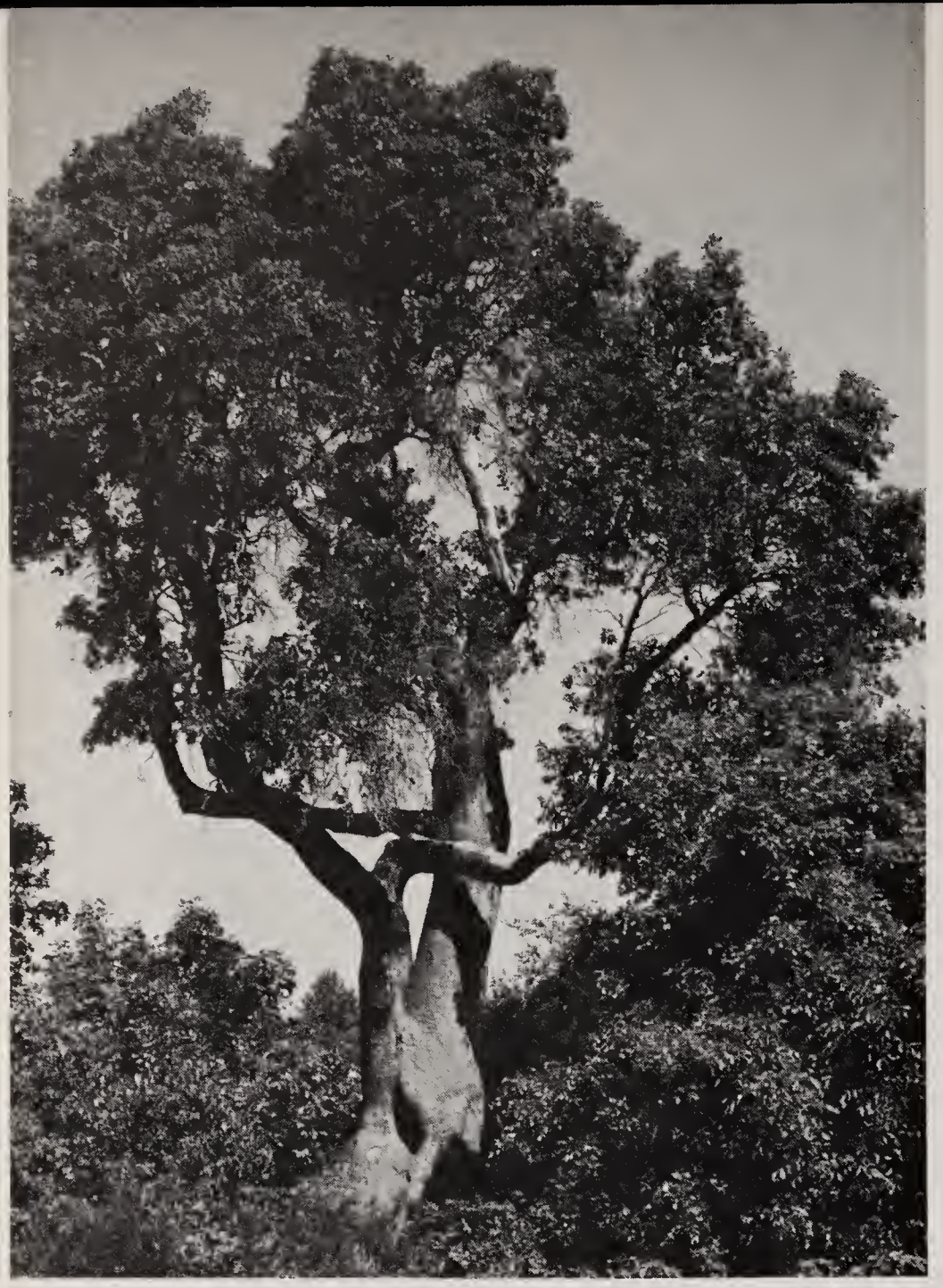
Those who enjoyed the series of articles on the genus Nothofagus *in the* Arboretum Bulletin *(41:1, 1978), will be interested to read the following excerpts from a letter to Brian Mulligan from the Earl of Bradford in Shropshire, England:*

"I was very interested to receive a day or two ago a copy of your Arboretum Bulletin, Volume 41, No. 1, with the articles on Nothofagus. These are of great interest to me as I am trying now to grow here and in Devon as many as possible of the temperate species of Nothofagus from South America, New Zealand and Tasmania, including some of the less common species such as alessandrii and glauca. Many of them show very great promise and adequate hardiness, though some are susceptible to Spring frosts and cold winds, especially dombeyi which is otherwise such a beautiful and vigorous tree.

It may interest you that I have a rather unusual hybrid between Nothofagus obliqua and Nothofagus menziesii, some of the seedlings, now two years old, being deciduous, some evergreen, and some unable to make up their minds which to be. I think this is an unusual occurrence, though whether the resulting tree will be of any great value rather remains to be seen. There is a great and growing interest in the genus over here and a great demand for trees, which we are trying to meet."



The madrona at Martha Washington Park. Photo: J.A. Witt

Ancient Madrona and a Stand of Garry Oaks in Seattle

JOSEPH A. WITT

Early last year I received a request to examine some trees on the grounds of the old Martha Washington School for Girls on the shore of Lake Washington south of Seward Park. This property, now a city park, had once been extensively landscaped and there were several large, somewhat uncommon trees growing there. I was very surprised, however, to find a semi-wild area between the school buildings and the lake which contained two most remarkable native species.

The first was what must be the largest madrona *(Arbutus menziesii)* in Seattle, and perhaps in King County. This great-grandfather of a tree was growing on the edge of a steep bramble-covered bank and it was with some difficulty that we were able to measure its diameter. When we finally did get the tape around its trunk, we found it was 74.3 inches in diameter breast high, or about six feet two inches through. Because of its location on the steep bank, the measurement was not actually taken at the usual 4½ feet above the ground since the ground line on the east side of the tree was probably 6 feet below that on the west side. The trunk was hollow from a point near the ground on the east to perhaps 15 feet above the ground on the west; on a later visit we found that someone had placed a rope ladder through the cavity. Its height was about 75 feet, and despite several other cavities, wounds and broken branch stubs, this fine specimen seemed in excellent health.

Large as this specimen is, it is nowhere near the record size for madrona. The largest tree recorded (1)* is located in Humboldt County, California and measured 117 inches in diameter breast high and 80 feet tall. It has, therefore, a diameter about 2½ feet greater than the Martha Washington tree.

Even more surprising to me was a small grove of Oregon white oak *(Quercus garryana),* since I did not know that this tree was native within Seattle's city limits.

Quercus garryana is Washington's only native oak and has a rather interesting distribution within the state. It is found west of the Cascades growing in gravelly well-drained to deep loamy soils from the Columbia River north through the Puget trough to the Canadian border. Relatively common south of the Nisqually Prairie near Tacoma, the Garry oak is rarer north of this point, being found in small isolated groups and groves mostly near Puget Sound and typically in sites where

*Numbers in parentheses designate references listed at the end of the article.

natural prairies occurred. There are such locations near Sequim, at the north end of Whidbey Island, and in the San Juan Islands as well as near Bellingham.

It also extends into the south central part of the state along the Columbia River and on the east side of the Cascade Mountains into Yakima and Klickitat counties.

Since Garry oak is not a common tree in the vicinity of Seattle, at first I thought that this group may have been planted at the school. On further investigation, I discovered another grandfather (or perhaps better, grandmother) tree which must be much too old to have been anything but a native to the site. This big old veteran had a trunk 53 inches in diameter breast high and although the top was broken out, it was still over 75 feet tall. Knowing how slowly our introduced *Quercus garryana* have grown in the Arboretum, I had to believe that this tree is well over a hundred years old.

There are a number of smaller oaks nearby which might be offspring of the larger tree and I took an increment core from one that was 24.6 inches in diameter. Since the wood was exceptionally tough, I was able to get a core only 8½ inches long. This core contained 60 growth rings or about seven per inch; since its radius was 12.3 inches the tree would seem to be between 80 and 90 years old. In other words, it would have started growth in the late 1890's. I realized it is most inexact and unscientific to make such extrapolations, but I made a further one and assumed a similar rate of growth for the larger specimen and arrived at an age of about 186 years, or a germination date of 1792, long before the Seattle area was settled.

These figures are doubtless on the conservative side and the trees could well be much older than this. Age measurements are not easy

Sixty-foot *Quercus garryana* in Martha Washington Park. Photo: J.A. Witt

to find for Garry oaks but Sudworth (2) states that "...trees, respectively 19½ and 27 inches through (inside of bark), were 183 and 250 years old." *Silvics of Forest Trees of the United States* (3) remarks that trees 250 years old seldom are more than three feet in diameter.

The Seattle Park Department has a record of this small park from which I discovered that it was part of a land claim of E.A. Clark who sold out to David Graham in 1852. The latter then traded this property to Walter Graham who is said to have planted an orchard in the "uplands" around Seward Park. It is possible that the orchard extended into the level ground west of the site where the oaks and madrona are growing. The first record of a building was when John Wilson built a home in the center of the present park site a few years before 1889. Judge E.T. Smith purchased the land in 1892 (about the time when the oak I measured was germinating); in 1921 he sold it to the Seattle School District; the park department acquired the land from the School District in 1972. Since this abbreviated history gave very little information that would explain how these oaks happened to be there, I consulted the Herbarium of the U. of W. Department of Botany to see what record they

Trunk of the madrona. Photo: J.A. Witt

had of the occurrence of Garry oak in the Seattle area. The few herbarium sheets for this region were as follows: one from Three-Tree-Point a few miles south of the city; another, dated December 14, 1904, stating "Seattle, scarce on hillsides," attributed to *Q. garryana* but probably a specimen of the English oak *(Q. robur);* and a final sheet collected at Oak Lake in 1890. Which "Oak Lake," or where, was not specified, but it may have been the now defunct pond for which Oak Lake School at N. 100 and Aurora N. was named.

One other tenuous bit of information about the occurrence of Garry oak near Martha Washington School remained. I remembered an article in a local paper perhaps 15 years ago stating that a large oak had been cut down in a garden near Seward Park and that some forestry student had said it was well over 100 years old. This stuck in my mind since I questioned at the time that there could be an introduced oak of that age. It now seems that this tree could have been a native Garry oak.

I now believe that the oaks at the park represent a natural stand of *Q. garryana* occurring within the city limits of Seattle, and as such I think they must be more or less unique and should be preserved. In all, I counted seventeen oaks: two over 24 inches in diameter, one between 15 and 20 inches, two between 8 and 12 inches, nine between 4 and 8 inches and only three smaller than 4 inches. Since the steep bank on which they were growing was covered with blackberries, I did not make a very thorough count and it is possible that I may have missed some smaller trees. I also saw evidence of at least one oak stump over 24 inches in diameter. At least one of the smaller trees had acorns but I saw no seedlings or young saplings. One of the smallest trees had its top cut off about three feet above the ground and I was able to count between 20 and 25 growth rings. It appears that there may be some regeneration on the site but that it is sporadic and weak.

We may ask how this little relic stand of oaks growing on the shores of Lake Washington ever became established. Was the present park site one of the tiny open prairies that were scattered among the ubiquitous conifer forests which covered Western Washington in the early half of the Nineteenth Century? If so, could it have been the site of an Indian settlement or gathering place? An interesting speculation on the origin of the discontinuous pattern of oaks is to be found in a paper by Taylor and Bass (4) from Western Washington University. These authors note that many of the isolated groves of Garry oak coincide with Indian settlements and suggest that since acorns were an item of the Indian diet, the oaks may either have been planted or represent lost acorns that found a suitable site in which to become established. Parenthetically, they also point out that the Indians may have camped where there were oaks.

If any of the *Bulletin* readers know of other stands of Garry oak in or near Seattle, please call or write the Arboretum with this information.

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Remember: Arboretum Foundation Plant Sale
May 2 & 3 (See p. 31 for details).

Sword ferns on a forest floor. Photo: Brian O. Mulligan

Gardening in Green—Woodland Ferns

*SUE OLSEN**

She was a plant sale customer, sincere, friendly and firmly insisting that her staghorn fern had giant pink flowers. She was also wrong. Ferns don't give us flowers (I assume the lady's "staghorn" was Aechmea fasciata*), but their richly varied greenery brings peace and unity to our gardens. We may choose from the hundred species of the world's ferns that are native to the Pacific Northwest or from the many interesting horticultural imports that adapt readily to our climate. The following article catalogs a few of the taller woodland species that are ornamental and have an easy disposition in our landscapes. The lower growing varieties will be featured in a future article.*

In our extended backyards, along our highways, and banking the Pacific slope grows one of the easiest and most tolerant of handsome ferns. A two- to three-foot evergreen, it is accustomed to the idiosyncracies of our climate, adapted to our soil and compatible with its shady fellow travelers. All these and more is *Polystichum munitum,* our common and oft neglected sword fern. As with salal *(Gaultheria shallon),* this lovely plant's single shortcoming is its abundance. No one points with pride to his fine specimen of *P. munitum.* Instead, human nature challenges us to struggle with the rare, the imported and the devilishly difficult. (As I try to establish some of the Arizona "gems" temperamental in our habitat, I can't help but wonder if I have a counterpart somewhere in the arid southwest who is desperately trying to get a sword fern going.) Meanwhile *P. munitum* goes on quietly doing its job, beautifying and unifying our shadelands. Start with it, continue with it, and use it, but don't put the poor willing pteridophyte in the sunny rockery where it will suffer but survive.

I am frequently asked whether the fronds should be sheared. In tidy intimate areas it is probably necessary, but otherwise the composting fronds improve the soil and produce taller growth without really looking unkempt.

Two native polystichums less frequently encountered are the closely related and easily confused *Polystichum andersonii* and *P. braunii.* Depending on your botanical bent, the differences may be merely geographical variations. The easiest identifying feature of *P. andersonii* is the frequent presence of a growth bud at the tip of the frond (which will be happy to reproduce if pinned

*Sue Olsen is one of the most knowledgeable fern growers in the Pacific Northwest. For a number of years she has directed the annual fern sale sponsored by the Northwest Ornamental Horticultural Society, which will take place this year June 14 to 16, in the Bellevue Square Pavilion.

down in humusy soil). More technically, the lower pinnules on the upper side are larger and more upright than on *P. braunii* (here's where a picture's worth 1000 words), and the leaflets are not completely cut. *P. braunii* lacks the bud, the pinnae are symmetrical and they are completely divided. Both are fountains of emerald fronds two to three feet tall, treasured for year-round brightness in the woodland.

J.W. Dyce (1)[1] calls the British Isles the epicenter of cultivation of fern varieties, so it is no surprise that at one time British botanists described upwards of 365 varieties of *Polystichum setiferum.* Nurserymen may yet overtake them with common names, for one variety alone is variously named Swedish fern, Iceland fern and most frequently Alaska fern, the latter probably because its cousin, *P. braunii,* was once called *P. alaskense*. The setiferums are truly feathery forms usually bipinnate, but often tripinnate and the plumiest selections of all quadripinnate. Many have a mossy cushion-like appearance looking like the soothing verdure of the undercover in a tropical rain forest. By contrast, other forms are garnished with tassels, crests and crested crests, seemingly needless clutter by mother nature. The *P. setiferum* nomenclature is a thicket of -lobums, -ulums and -atums; therefore the following handful of names is presented as they are most likely to be encountered in the marketplace: *P.s. acutilobum* ('Proliferum,' *viviparum*) has long tapered fronds, essentially the standard of the classification; *P.s. rotundatum* is similar, but with rounded shiny pinnules; the fronds of *P.s. angulare (rotundatum cristatum)* have long branches at the apex; *P.s. polydactylum* has tips dangling with many green fingers (Frankenstein would approve); *P.s. congestum* is a valuable six- to eight-inch dwarf; *P.s. latipes* has a dark green, open lattice form; *P.s. pulcherrimum* is a finely divided filigree; *P.s. plumosum* is the "elite...a mass of finely cut greenery" (2, p. 151). Surely there's a *P. setiferum* for everyone's fancy. In addition to their beauty, they are extremely easy to cultivate, although care must be taken, since a blast from the hose will decapitate the heavily crested varieties. While summer shade is required, they are wintergreen even in winter sun and are consequently an asset, providing continued color under deciduous trees. They usually have a spreading, horizontal habit befitting their frequently proliferous nature. The vegetative buds lining the fronds will root when pinned down and produce a passel of fernlets in one season. It is, of course, easiest when the frond is left on the parent fern until the plantlets are well established, but a gift frond will multiply when firmed in a flat with peat, sand and leaf mold in whatever proportions are on hand.

Periodically the familiar *Polystichum setiferum* types are labeled *P. setigerum;* however, the British and European forms are *P. setiferum,* and *P. setigerum* is limited to those indigenous to America. *Polystichum* specialist David Wagner has recently relocated *P. setigerum* in British Columbia and Alaska.[2] He describes it as a more robust *P. andersonii* but without the latter's buds, in all likelihood a hybrid species between *P. munitum* and *P. braunii.* It is of interest to gardeners as a worthy evergreen landscaper and to botanists because it is a hexaploid (246 chromosomes!).

Polystichum polyblepharum comes to our gardens via the houseplant trade complete with its attendant haphazard string of names (*P. setosum, P. discretans,* and for no apparent reason, the tassel fern). It is choice indoors and exceptional outdoors with glowing glossy fronds growing in a typical polystichum arch to a height and width of two feet. Like all polystichums it is evergreen. It does, however, have a higher moisture requirement than most ferns, and is most lustrous when grown in moist, well-drained

Polystichum setiferum variety with low-growing ground covers. Photo: Don Normark

[1]Numbers in parentheses refer to literature cited at the end of the article. Nomenclature is based on Kaye (2) for horticultural forms and exotic ferns, on Taylor (3) for natives. Occasionally, if a reliable source is available, named cultivars are indicated by single quotation marks.

[2]Personal communication. Dr. Wagner, Assistant Professor, Biology, University of Oregon (Eugene), did his graduate work on northwest ferns at Washington State University (Pullman).

shady areas. And it is permanently unforgiving if allowed to dry out.

New Zealander *Polystichum richardii* serves in our gardens just as *P. tsussimense* does in flower arrangements. With triangular fronds a silvery navy green—almost black—it provides a complementary foil for wispy wildflowers such as *Soldanella,* violas and low growing aquilegias. It is a somewhat tender plant, needing the protection of a shaded southern exposure. While the north side of the house is recommended as having ideal light requirements for ferns, it is fully exposed to cold fronts and the usually accompanying desiccating winds which are destructive to north-facing plants of any kind.

I strongly believe that we should be more adventurous about testing indoor ferns outdoors in the Pacific Northwest. The two preceding species were formerly the exclusive possessions of houseplant enthusiasts and have certainly enriched our garden experience by their wider use as hardy plants. If the Philadelphians can uncover a sturdy *Davallia,* surely we in the northwest have the potential for establishing a larger collection of plants hitherto considered tender. It seems reasonable, for example, that a planting of *Pteris cretica,* which is hardy high in the Himalayas, should produce an acceptable form for our gardens. So go forth ye houseplants!

Blechnum spicant, our native deer fern, is an outstanding naturalizer for woodland gardens. This dimorphic plant has sterile fronds in a horizontal evergreen rosette, with fertile fronds stretching skyward. Averaging two feet at maturity, it is useful in landscaping for its strong vertical lines and makes an especially attractive planting grouped beneath Douglas firs with rugged low comrades such as wild ginger *(Asarum caudatum), Cornus canadensis* and twinflower *(Linnaea borealis).* Water well!

The versatile dwarf *Blechnum penna-marina* will be described in a future article, but it should be observed here that Kaye makes note of two other blechnums from New Zealand hardy in the British Isles, *B. discolor* and *B. capense,* which should be tested. The latter is described in a tantalizing understatement as "somewhat variable from a few inches to 10 ft." (2, p. 168). Blechnums are consistently elegant and it seems likely that future garden treasures will come from this genus.

The polypods ("many footed") bring the woods into our gardens. They make restrained carpets, spreading by creeping rhizomes (the "foot"), which should always be placed on the surface of the soil when planting. *Polypodium glycyrrhiza,* the familiar cloak of big leaf maples *(Acer macrophyllum),* and less familiar perhaps as it grows in curious combination with sedums on our coastal rocks, is a reliable sort that is willing in any loose soil. Our coastal *Polypodium scouleri* is a chubby-lobed species with radiant foliage. It usually adorns spruce trees along the Pacific shore, but is quite content in our inland landscapes, especially when provided with year-round shade. Both *P. scouleri* and *P. glycyrrhiza* have golden sun spots, large sori sprinkled on the underside of the blade, and look well in a raised planting which affords a view into and under the foliage.

Many strains of the common *Polypodium vulgare* have evolved in Great Britain—where else?—and occasionally reach our markets. Looking as if they have been run through a shredder to various degrees, they are all refreshing additions to the garden. Many of the polypodiums are semi-dormant in the summer, and it is not unusual to have the new growth come as late as September.

Catalog perusers may notice a predominance of *Dryopteris* in eastern offerings. (That's anything on the far side of Spokane.) It is one of the few genera that has an extensive selection of sturdy North American natives. Of the many available, our northwestern *D. dilitata grandiceps* is a highly prized garden specimen. With dots of green drops on its skeletal frame, it is one of the most open and airy of woodland ferns. In new growth it is mildly two-toned, resembling the spring coloring of a conifer. Later there is a predominance of rusty scales on the two-foot fronds, which complement plantings of heavily indumented rhododendrons. The plant forms a wide-fanning clump which, while evergreen, is likely to lie down during winter.

The sub-evergreen *Dryopteris filix-mas linearis polydactyla* is variable from sparse to substantial, and is inoffensively branched at the ends of the pinnae. Eventually reaching two feet, it gets better looking and is sturdier in the garden as it ages.

Throughout the last decade the lack of ferns available in general nurseries has inspired the growth of a hobby trade. The impetus must have come from such species as *Dryopteris erythrosora,* a striking and sturdily reliable evergreen

from eastern Asia. Called the rosy fern and/or autumn fern by the indoor growers because of its rich coloring, its new growth is a warm rose-copper color blending into green as the frond approaches full growth of two plus feet. Even the sporangia are covered by red indusia. When planted with the tall Triflorum Series rhododendrons, especially *R. lutescens* and *R. yunnanense,* and edged with *Blechnum penna-marina* in the foreground, it is the basis for a fine garden composition. They should, however, be protected from strong winds.

Dryopteris erythrosora var. *prolifica* is even more graceful and beautiful than the type having the same coloring but less foliage. It can be reproduced from infant buds along the frond.

Many of the Japanese dryopteris are noted for colorful new growth, but not always because of the hue of the fronds. Some species exhibit a striking contrast between a heavy coating of dark chestnut-brown or black scales on the stem and the bright apple-green unfurling foliage. A noteworthy example of this group is *Dryopteris wallichiana,* a sturdy tall-growing, sub-evergreen which is handsome in shady combination with yellow spring-flowering plants, such as *Epimedium versicolor* 'Sulphureum,' under a canopy of light-leaved Japanese maples. The fronds, like the tree leaves, will darken with age but will remain radiant. The closely related *D. atrata (hirtipes)* is darker in all aspects but similarly showy with its contrasting parts. *Dryopteris polylepis* sprouts such a coating of scales in new growth that it appears to be a plant without chlorophyll.

At the other end of the spectrum is *Dryopteris varia* with wispy whitish gray scales offset by the bright green frond. In *D.v.* var. *setosa* which usually has new red foliage, the scales give an unusual pink feathered effect to the fiddlehead.

While many of our rock ferns tend to be a reflective stony blue, that color is not often seen in woodland species. But *Dryopteris sieboldii* is unique and unfernlike in all respects. With its dagger-shaped blade suggestive of some of our Mexican (indoor) polypodiums, it paints a bold splash of blue in the landscape. It grows very slowly from spore and subsequently is maddeningly late with its new growth—tender summer morsels which must be protected from the ever-waiting slugs. Once developed, the evergreen fronds are generally around eighteen inches to two feet tall.

Cyrtomium falcatum, the familiar florist's plant, will tolerate more shade than any other fern indoors or out. It is somewhat slow to establish, and its evergreen foliage naturally tends toward the yellow side of green. If it seems excessively chlorotic, an iron supplement (Geritol?) may be added to the soil taking care not to get it or any other fertilizers on the crown of the fern. I am particularly fond of the veining design on the *Cyrtomium* pinnae as an example of the beauty of the patterns of nature. Three other *Cyrtomium* species, *C. fortunei, C. macrophyllum* with huge pinnae and the newly available *C. juglandifolia,* have proven hardy in the benign climate of western Washington and Oregon.

Some of the most promising new introductions to fern cultivation are the Japanese imports. Leaders among these are the species of *Arachniodes* (the erstwhile *Polystichiopsis, Polystichopsis* and *Polystichum*). Far from appearing spidery, these perfectly hardy evergreens are strong, bold, leathery and lustrous. *Arachniodes simplicior* and var. *major* have very broad ovate fronds of such a rich dark green they appear coated with leaf gloss. In good soil, plan for substantial growth to a height of three feet with an almost equal spread. Well-described by its name, *A. aristata* is a dark glowing green with a patent leather polish. This and its variety *variegata,* which has a mild light green to golden stripe down the midrib of the foliage, are leathery enough to take a considerable amount of sun although their size will be greatly reduced to about 15 inches. These are exciting and easy plants for the collector and reliable for the layman.

The hart's tongue fern, *Phyllitis scolopendrium,* has been in cultivation for centuries and is a recurrent feature of old herbals and poetry. When properly mixed with wine it reputedly cures snake bites, burns, ulcers, liver ailments and heartbreak.

Polypodium scouleri. **Photo: Don Normark**

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(To the best of my knowledge, there are no poisonous ferns although some, such as bracken and *Osmunda,* used in oriental diets, are believed to be carcinogenic.) This fern is unmistakable in the landscape because of its totally unfernlike silhouette. Its simple undivided fronds grow in a spreading vase-shaped clump to 18 inches. A good light green evergreen for deep shade to part sun, it is especially effective planted with sunny back-lighting to highlight the pattern of the sori, which are lined up like so many buttonholes on the underside of the fronds. Although it is traditionally associated with lime, it adapts to our more acid soil. I try to compensate if not the plant at least my conscience by periodically tossing crumbled egg shells around my lime lovers as well as by including a chunk of broken concrete in my planting mix.

Phyllitis scolopendrium has given rise to an endless number of varieties. They range from shrunken and shriveled and distractingly parsley-topped to undulant, rippling, refreshing garden subjects. Among the latter, two are most likely to be available: *P.s.* var. *muricatum,* whose frond has a stiff ridged edge, is considerably lower growing and performs well as an edging plant in part sun; *P.s.* 'Laceratum,' Kaye's variety, is so fresh and leafy it looks as if it should be in a salad bowl. The latter is low and light green and makes a good underplanting for taller ferns, such as the arachniodes.

While most ferns are propagated primarily by growing them from spore or by division, *Phyllitis* is one that supposedly can be grown from old frond cuttings. The method suggested is to lift the plant and cut back the rootstock to living tissue. The frond bases can then be snapped off and replanted to form new plants.

A fern of poets, a fern of water, a ferny fern, a fern of ferns, *Adiantum pedatum* grows from the splash zones of creeks and rivers to our cool mountainsides, and discovering it is always a pleasant outdoor experience. Called the maidenhair and the five finger fern by virtue of its unusual outline, it has delicate greenery on top of a brittle black rachis and is actually quite a husky clump-forming plant. In our gardens it is happily situated in any shady location and while not necessary for the health of the plant it flourishes and looks well in association with water.

Our climate supports other resident adiantums (*A. subpumilum,* the dwarf conglomerate, will be covered later). Some are adapted to particular and peculiar ecoclimates that are difficult to duplicate in our lowland residences. These include: the Wenatchee Mountain form, var. *aleuticum* of *A. pedatum,* a vertical, sun-loving plant with sopping feet and impossible serpentine-soil requirements; *A. jordanii,* obstreperous for no verifiable reason; *A. capillus-veneris* which requires extra warmth, but is otherwise tractable. While I find fern hybrids unnecessary except perhaps to breed for slug resistance, I'll do anything for another maidenhair, and we do have a collector's treasure in *Adiantum* × *tracyi,* a natural hybrid between *A. jordanii* and *A. pedatum.* Its leaflets are more rectangular than those of *A. pedatum,* and it forms a refined, spreading evergreen clump. Unfortunately it is sterile and we must depend upon division for new plants.

Adiantum venustum has such a sylvan delicacy that it is hard to believe it is not a tropical fern. However, its homeland is the Himalayas, and it is reliably enduring in our gardens. Truly a first rate plant, it forms a spreading evergreen carpet from eight to twelve inches in the shade, where it enlivens heavy plantings of evergreens. It will reach for and can tolerate small doses of sunshine. By contrast, *A. monochlamys,* while also evergreen, displays its delicate fronds in a dense cluster. Light and sprightly, it looks well nestled against a stump or a log.

Although they are deciduous, the several osmundas make attractive large specimen plants. This ancient genus can sketchily trace a family tree back some three hundred million years to the lush prehistoric days when horsetails were 20 feet tall (and we think they are a problem now!) and most certainly had some forefathers whose fossils are now in our coal fields. The most popular today is *O. regalis,* the royal fern, an east coast native whose fronds resemble locust tree leaflets. The new growth has a subtle russet overlay which recedes to a medium green as the fronds extend to their eventual height of three feet or more. To the mutual enhancement of both, *O. regalis* naturally associates with water and unlike most ferns may be successfully established in boggy situations. By reputation it resents transplanting; however, because of the inherent difficulties in growing this particular genus from spore, it must be presumed that nursery-offered specimens are being distributed (ah, trans-

planted) directly from the wild. For safety's sake, though, especially if the plant is to reach its maximum potential of six feet, it is certainly advisable to be sure of the site and selection of companion plants before placing it in the landscape.

Because the sporangia of *Osmunda regalis* are borne on stalks extending from the frond, it is sometimes called the flowering fern. This arrangement (as opposed to the more familiar underleaf location) is indicative of the primordial status of the genus. Lacking sophisticated mechanisms for gradual dispersal, the spore are unprotected and green when ripe, maintaining their viability for just a few weeks or slightly longer with refrigeration. As a result it has been difficult to obtain some of the finer imports such as *O. lancea* from Japan, a lower-growing and more spreading species with all the visual advantages of *O. regalis* but more suitable for the smaller water garden.

Unaccustomed as I am to endorsing crested ferns, *Osmunda regalis* var. *cristata* is magnificent, with mild cresting that stays in good proportion to the plant. Specimens have been reported to grow up to 14 feet in circumference (a little centerpiece perhaps for the hot tub)!

Osmunda claytoniana, for obvious reasons commonly called the interrupted fern, carries its sporangia midway up the frond, leaving foliage at the top and bottom of a brown midsection. To the unprepared its appearance can be quite alarming, but the fern is not diseased. Like its relatives, it can be very tall but is distinctly fastigiate in habit. With adequate moisture any of the osmundas will accept a fairly sunny exposure.

The gourmet's fiddleheads with their asparagus flavor are harvested from *Matteuccia struthiopteris,* the ostrich fern, our neighbor to the north and east. It is an easy, vigorous grower reaching to five feet in height with the sterile plumes forming a fairy ring around the lower-growing fertile fronds. The latter are persistent although turning almost black, while the taller fronds are fully deciduous. Use it for background mass in alluvial to swampy soils.

Two statuesque woodwardias are outstanding additions in gardens with a climate tempered by the presence of a nearby body of water, or those in which a protected site can be artificially created. They are called giant chain ferns—and giants they are—but they are named for the spore

Athyrium iseanum pictum. **Photo: Don Normark**

pattern which suggests long chains of sausages. In nature they can be a full nine feet fall albeit a more modest six feet is the standard. Visually they are extremely useful in areas calling for the stately grace usually associated with tropical plants. *Woodwardia fimbriata* is our west coast native. The Japanese *W. orientalis* has distinctive unfurling fronds of red. Both are deciduous.

Ferns may not flower, but their greenery is varied. Most subtle and refined in its beauty is the unusual *Athyrium iseanum (goeringianum* or *nipponicum,* depending on your most recent reference*) pictum.* Muted shades of pastel gray, green and blue radiate from the frond's maroon midrib like the smoky tones of an early morning fog. A pleasing garden picture in combination with red-leaved maples, it sends up new fronds throughout the summer. Spore-grown plants show considerable variation between the variety *pictum* and the type, which in itself is an attractive plant with pale green leaves. These deciduous ferns are also the only ones that go dormant in my growth chambers.

It would be wrong to write about tall ferns without including *Athyrium filix-femina,* the not-so-lady-like lady fern, which often shows up in our gardens whether we want it or not. It invariably sows itself dead center in some choice plant and, once established, is exceptionally difficult to eradicate. The fern, if one suspends judgement, is not really unattractive and might be acceptable were it not for its rampant habit. It belongs in meadows, preferably a good distance away from Bellevue, although spore have been known to float from Japan to Colorado. As with *Dryopteris filix-mas,* a male chauvinist fern that is equally as willing to take over the garden, there are endless varieties (see Kaye for 60 of them) that form a great undefined collection known at plant sales as

English crested ferns. Some are very attractive and others remind me of ladies in curlers at the grocery store. Several are so unique, however, that they must be catalogued. *Athyrium f.f.* 'Frizelliae' has pinnae so small that they look like little tufts of green cotton attached to the plant's stem. *Athyrium f.f. fieldii* pinnae cross back over themselves and look like poised butterflies. *Athyrium f.f. victoriae* is also cruciate but with elongated (though still small) pinnae that are crested at the tips. All of these are deciduous with a specialized form that does not readily blend into a landscape design, but they may be featured for their individuality.

The above listing is but a smattering of the possible. *Hardy Ferns* by Reginald Kaye (2) and *Pacific Northwest Ferns and Their Allies* by T.M.C. Taylor (3) make fine fireside companions for more extensive descriptions. Technical data from Japan are published in Jisaburo Ohwi's *Flora of Japan* (4).

Thanks to Seattle's Neill Hall, Director of the American Fern Society's spore exchange, an ever-increasing number of otherwise unobtainable species and varieties will continually be tested and introduced, albeit in a lopsided fashion, via the hobby growers who may have 300 plants of a given species one year and a totally different selection the next.

And finally I agree with Bill Hatheway's conclusions: "Many of our collections of ornamental plants, especially those from the southern hemisphere and the tropical mountains, represent very restricted samples of what is available in nature" (5). There are many valuable garden subjects yet to come. Think of the fun!

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Sargent's Fir "Hybrid"

One day in August 1896 Professor C.S. Sargent, founder and first Director of the Arnold Arboretum at Boston, Massachusetts, was collecting in the western part of the Olympic Mountains of Washington on a ridge between the Bogachiel and Soleduck Rivers at about 4500 feet elevation. Among his specimens was one which, on the basis of leaf and cone characteristics, he believed to be a hybrid between two species of fir, *Abies amabilis* and *A. lasiocarpa*.

Dr. W.B. Critchfield[1] has examined all available information regarding this specimen. After careful study and comparison of the material, he concludes that it is undoubtedly only an example of *Abies amabilis,* although its cones are somewhat smaller than normal for that species but larger than usual in *A. lasiocarpa*. The foliage characters agree well with the former. The same conclusion had also been reached by W.H. Lamb in 1912, as a note with the cones indicates.

There is still no authentic record of a natural hybrid between these two western species, or of hybridization between *Abies amabilis* and any other species with which it grows naturally.

On the same day of this trip into the Olympics, Sargent also reported finding a tree of the noble fir *(Abies procera)* near the Soleduck River. Dr. Critchfield has also reexamined the specimen of this tree, which is in the herbarium at the Arnold Arboretum, and he finds it to be *A. lasiocarpa,* although the elevation from which it came (3000 feet) is low for the species.

G.N. Jones, in his *Botanical Survey of the Olympic Peninsula* (1936, 1947), stated: "There is, however, no recent evidence of the occurrence of this species [*Abies procera*] in the Olympic Mountains." He could safely have omitted the word "recent."

B.O.M.

[1]Dr. Critchfield, of the Pacific Southwest Forest and Range Experiment Station, Berkeley, California, has published his findings in the article, "Sargent's Fir Hybrid: *Abies amabilis* × *A. lasiocarpa,*" in the *Journal of the Arnold Arboretum,* 58(1):52-59 (January 1977).

Rhododendron thomsonii. Drawing by Hazel Thelen**

Progress in Rhododendron Classification

*FRANK DOLESHY**

Editor's note: An International Rhododendron Conference held at the New York Botanical Garden during May, 1978 was intended to be the first step in a concerted effort to obtain agreement on the classification of this enormous genus. The Bulletin's *editorial board has asked Frank Doleshy, who attended the conference, to write the following explanation of the urgent need for the proposed revision and the probable effects it will have on familiar* Rhododendron *nomenclature.*

During the years from 1900 to 1930, plant collectors found their way into remote parts of China, Burma and other Asiatic countries, discovering more than half of the 900 species now known, and creating a crisis for botanists and growers. Until that period, the introduction of new species had proceeded slowly enough for botanists to keep pace, using existing botanical classification systems. But the addition of so many new discoveries made several of the earlier botanical groupings large and cumbersome.

Confronted with this flood of new material to be identified or classified, the late Isaac Bayley Balfour and his co-workers in Edinburgh adopted a pragmatic approach, never intended to be a permanent botanical classification system. They divided the species into groups which they called "series." Each series, named after one representative member, was supposed to consist of species sharing certain features characteristic of the series namesake; for example, roundish, hairless leaves and loose clusters of bell-shaped flowers indicated membership in the Thomsonii Series, named after *Rhododendron thomsonii.* Identification consisted of acquiring a mental image of the representative plant for each series and proceeding from there.

Both botanists and growers adopted the 43 Balfourian series as an informal framework for identification. In practice, however, they had to contend with the fact that several of the species assigned to a given series might differ from the basic image; for example, some members of the Thomsonii Series had pointed rather than round leaves and saucer-shaped rather than bell-shaped flowers. Hence the series concept, although it helped simplify the identification process, contained flaws which often reduced the process of identification to a matter of trial and error or simple comparison. Recognizing these problems, but thinking the system essentially sound, some botanists tried to provide stronger boundaries between series, but because of inherent weakness in the system, it did not grow out of its initial limitations.

Nevertheless it persisted because it provided the first system which could easily be used by amateurs. Furthermore it supplied the framework for the first comprehensive treatment of rhododendrons grown in the western world, *The Species of Rhododendron,* published in Edinburgh (Stevenson 1930). Although the book provided keys for distinguishing the species

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*Mr. and Mrs. Doleshy are amateur botanists and horticulturists. They began growing rhododendrons one month before the notorious 1955 freeze in the Pacific Northwest, had a few survivors and decided to continue. For study and collection of native rhododendrons and associated plants, they have traveled to Japan five times and to Borneo once. Seeds from their collections have been distributed through the American Rhododendron Society.

**This botanical drawing is one of several hanging in the Arboretum Offices. They were created about 1955 by Hazel Thelen, who was a scientific illustrator in Health Sciences at the University of Washington.

within their series, it lacked an overall key to the series. This deficiency resulted from the above mentioned lack of definite boundaries. But the book remains a basic reference in English-speaking countries since it is the only comprehensive publication in our language.

The botanical system of classification, with its conventional subgenera, sections and subsections, was not subject to the limitations of the series concept, and work had progressed in this direction. Utilizing the strong points of both systems, Dr. Hermann Sleumer, then of Berlin University, undertook a synthesis of them in his paper, "Ein System der Gattung Rhododendron L." (Sleumer 1949). He assigned the series (complete or as fragments) to various niches of botanical classification; he also clearly defined the resulting groups, thus avoiding any carry-over of the indefinite boundaries between series. Rhododendron identification could now start from scratch: Flowers at branch tip or along the stem? Leaves with or without surface structures? Leaves evergreen or deciduous? These and further steps in Sleumer's key would lead to the subsection; then one could use finer distinctions for the relatively simple step of identifying the species. Although Sleumer's system filled the great need, it only slowly became known in Britain and America, mainly because of the lack of a good English translation of his paper.

Finally in the mid-1970's, many botanists and growers, having heard of Sleumer's work, felt that it was time to consider the results of consolidating the two systems. Seventy-five botanists and rhododendron experts gathered at the New York Botanical Garden for the International Rhododendron Conference from May 15th to 17th, 1978. Sleumer, ill in Holland at the time, sent the keynote paper. And, although some of the other conferees proposed modifications of his system, all of them recognized that it must be considered the foundation of current work on classification and nomenclature.

Learning of this conference, an amateur or professional grower will probably ask first about changes he would encounter in familiar *Rhododendron* names. He will find that Sleumer's studies resulted in some renaming, but that this did not amount to a sweeping revision. The grower may also wonder about replacing the familiar series with sections and subsections, but he will see that the translations are largely obvious; for example, Series Falconeri becomes Subsection Falconera. It is true that some series are merged or split, and some (such as the Thomsoniis and Barbatums) are taken apart and recombined, but the resulting groups appear to be more consistent.

During the next few years, the best source of information about the new classification will undoubtedly be the conference proceedings, scheduled to be published in 1979. (Until then, see other listed references.) The proceedings will be incomplete or tentative with respect to certain classification work that is still in progress, but these refinements should be complete in about four years.

To the great satisfaction of his friends, Dr. Sleumer has lived to see his work applauded the world over, and he had in fact recovered his health by September, 1978, reporting himself hale enough for three-hour walks.

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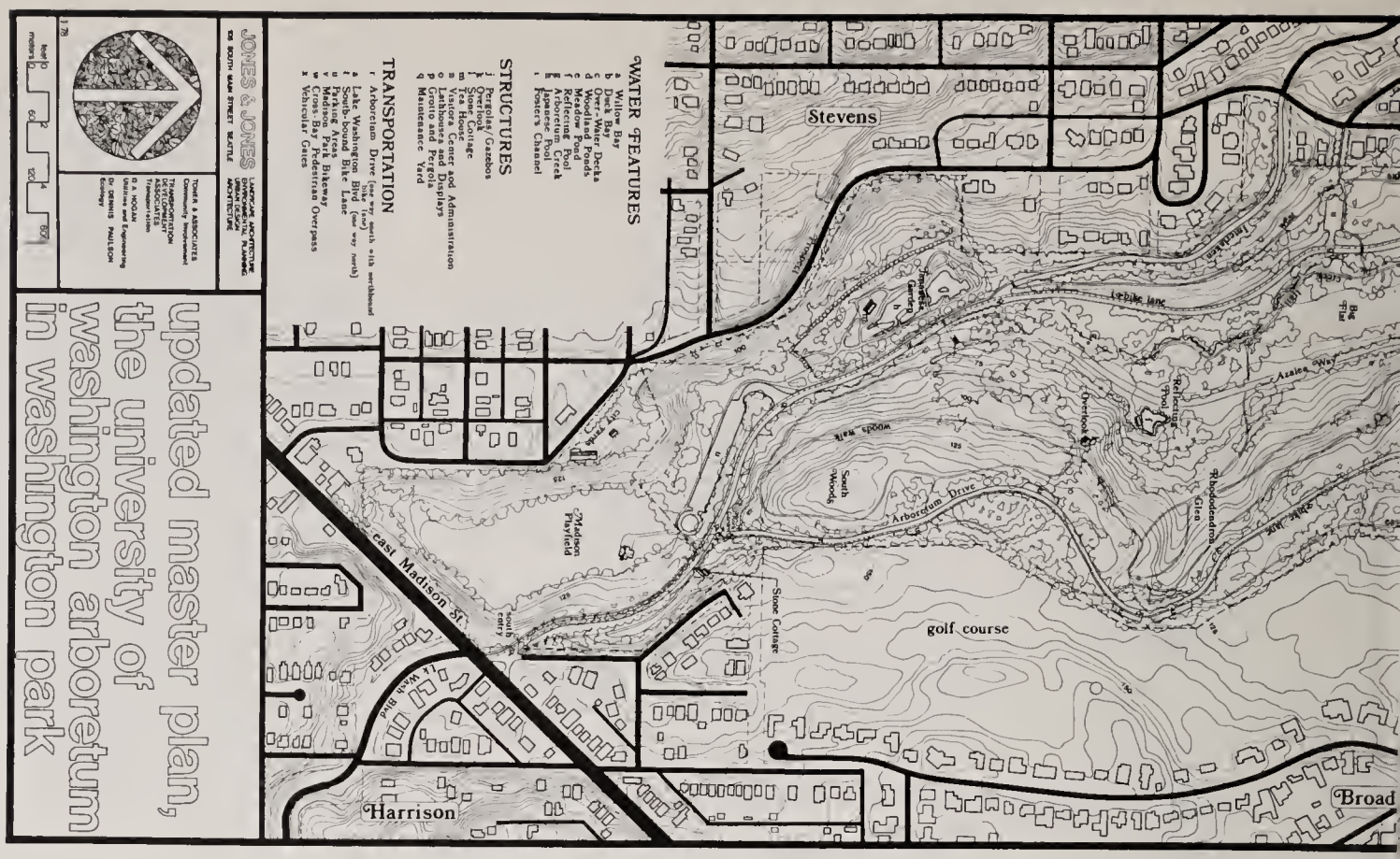


Map of
the Arboretum
according to
the Jones & Jones
Master Plan Update

President's Message

The Master Plan Update, designed to improve the Arboretum and to give it a new sense of beauty and purpose, is proceeding through the various steps necessary for its implementation. These steps are summarized below:

—The plan was drawn up, with much public participation, in 1977. In March, 1978 all Arboretum Foundation members were asked their opinions. Of the 250 responses (good, under the circumstances) 94 percent expressed support for the plan. One third of these also recommended a larger meeting or guided-tour assembly area or a larger office space. Many valuable ideas and suggestions were also received and were welcomed.

—The Draft Environmental Impact Statement (EIS) was printed and distributed late last year.

—The Parks and Community Services Committee of the Seattle City Council held an open hearing on January 10 on the draft EIS. The Arboretum Foundation was represented by many dedicated members who supported the plan and stated their belief that the draft EIS properly and fully addressed the effects of the plan. (The transportation, or roads, aspects of the plan were not a matter for discussion since they are only a part of a more far-reaching study by the city on the traffic patterns of the entire east central area.) There were also opponents of the plan present.

—There were meetings during January and February of various community, civic and garden clubs to secure a better understanding of the Master Plan Update. It is interesting to learn that, when these groups are given accurate and honest information, they tend to support the plan.

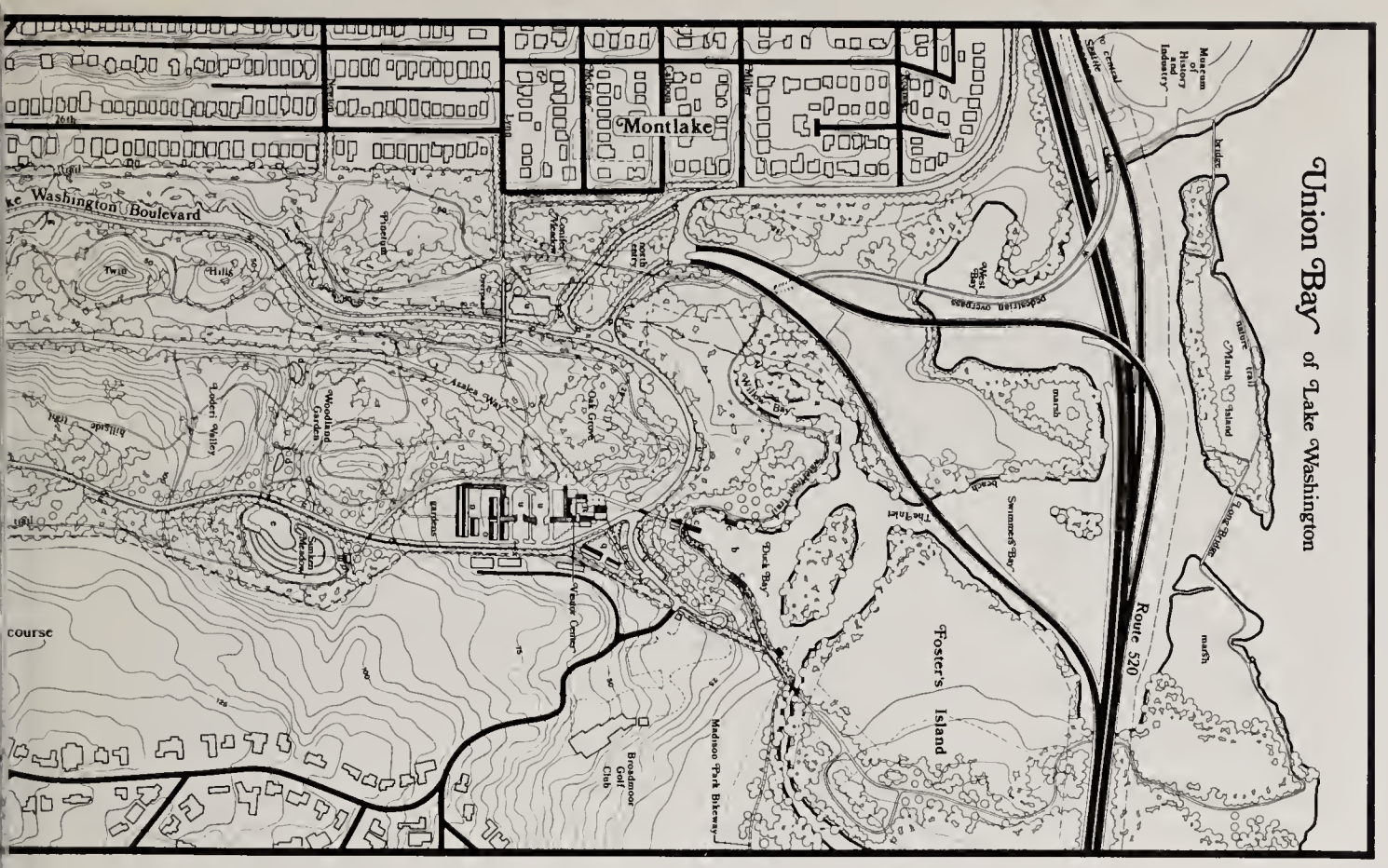
—Unit Council members are signing petitions and circulating them among wider groups, like offices and other work places. In addition, members are writing letters to Seattle City councilmen urging approval and implementation of the Master Plan Update. Garden clubs and other horticultural groups are doing likewise. These efforts are important to the City Council's approval of the plan.

—The current scheduling of the plan is for committee discussions (open to the public) on April 4 and 18. Then, on April 23 or 30 that committee will present its recommendations to the full City Council in open session. Attendance at these meetings by Foundation members will be helpful.

—After City Council action, the Board of Regents of the University of Washington will consider the plan.

The university has formed a search committee for a director of the U.W. Arboreta (Washington Park, Pack Forest, Bloedel Reserve and Union Bay). The Arboretum Foundation was asked to share its views on what type of person the new director should be. After canvassing the directors, active and honorary, those views were discussed with the search committee. Advertising and interviewing have begun.

Solutions are still being sought with the city on security and some adequate maintenance for the Japanese Garden. Once these are assured, fund-raising and actual building may begin. This is another matter in which letters to Seattle city councilmen can help.



The mayor and all councilpersons should know how we feel about the Tea House, and the Master Plan Update in general. Mr. George Benson chairs the Parks and Community Services Committee on which Mr. Sam Smith and Mr. Tim Hill also serve. The latter is also chairman of the Finance Committee.

As you can see, these are exciting and moving times. We in the Arboretum Foundation should be among the movers.

Leroy A. Collins, Jr.

Search for an Arboretum Director

The University of Washington has appointed a search committee to seek an Arboretum Director. This will come as good news to friends of the Arboretum, both within the University and the public sector who strongly support this need. The committee includes Dr. P.W. Cartwright (Special Assistant to the Provost), Dr. R.T. Buchanan (Chairman, Department of Landscape Architecture), Mr. Prentice Bloedel (President, Bloedel Reserve), Dr. S.P. Gessel (Associate Dean, College of Forest Resources) and Dr. L.C. Bliss (Chairman, Department of Botany).

To facilitate this search, the Committee has met with various public groups within the metropolitan area to seek their advice on qualifications of a Director and the evolving program. Nominations of potential candidates are sought as well as institutions to notify regarding this position. The position is being advertised in *Science*.

Applicants should have an advanced degree in some area of the plant sciences (for example, landscape architecture, ornamental horticulture, experimental taxonomy, plant ecology or plant physiology). There is a wide spectrum of faculty who have supported an expanded University Arboretum program and who will help form the nucleus of this teaching and research unit. The new director in concert with this group will be expected to develop a strong program of teaching, research, and public service focused around the University of Washington Arboretum and its various properties. Public service activities and fund raising from the public and private sectors are important aspects of this position. The University is committed to developing the Union Bay Arboretum and Botanic Garden, but needs the help of Arboretum supporters to insure that the state legislature permits it to use some of its dedicated funds for this purpose.

We look forward to an exciting period of growth and development for the Arboretum in what is recognized as an ideal location for an outstanding internationally recognized program of environmental horticulture.

LAWRENCE C. BLISS, Chairman
Search Committee,
Arboretum Director

Investment in Environmental Horticulture Provides Plant Survival and Low Maintenance

*BETTY MILLER**

Editor's note: Betty Miller (Mrs. Pendleton Miller) wrote "Challenge to Maintain the Green Scene," for the last issue of the Arboretum Bulletin *(41:4). At the time it was decided the subject of environmental tolerance of public plantings would not be covered adequately if a description of some of the beautification projects in and around Seattle was not provided. Here she discusses four such efforts. Although they are not in chronological sequence, we have arranged them first with problems faced and conquered, saving the successful Freeway Park and Operation Triangle for an optimistic conclusion.*

Much has been published claiming that we are utilizing too many available plants without thoroughly determining their adaptability to a specific environment. Horticultural knowledge required to select plants suitable to a given set of environmental conditions is frequently lacking. Early stages of the planning process rarely take into consideration the cost of appropriate site preparation or future maintenance, which are necessary to develop strong, healthy specimens and to insure a long life span. However, they are expensive items and must be treated as such during the early stages of programming and budgeting a project.

Just as the foundation of a house is essential to its ultimate strength, the health of a planting is dependent upon its site preparation. It would be better to invest funds in developing an appropriate site for the ultimate growth of a tree and plant a smaller specimen than to plant a mature tree with marginal site accommodations which will limit the probability of its survival. It is true that a plant can be kept alive with fertilizers and other artificial means, but these are best treated as emergency or booster measures rather than as its only source of survival. (Incidentally, for the most part our Northwest natives do not respond well to fertilizers.)

Another economic problem of threatening proportions: over the past decade our nation has been planting mature specimens on a grandiose scale, and this trend seems likely to continue. Where are all these plants to come from? We are facing a shortage that will cause the costs to escalate dramatically. New plantings of 10- to 15-year old specimens cannot be replaced in size indefinitely should they fail every few years.

The need for intensive research and education in the field of urban planting was discussed at a significant national conference held last November in Washington D.C. (see previous issue, inside front cover). The subject has invaded even such unlikely periodicals as the *Wall Street Journal*. That newspaper, in an article entitled "Horticultural Careers," stressed the need for future horticultural input: "...a survey of statistics by the American Society of Horticultural Science from 48 major universities/colleges over the past 10 years shows a 575% increase in horticultural enrollment and a 60% increase in all other majors...Professor Mastalerz, Pennsylvania State, tells his students that by the time they get their Ph.D's they should have about any job in the country they want."

Horticultural input will avoid costly failures! We will have no more choice plants victimized by root rot in containers without drainage, no more trees planted in sidewalk holes straddling the underground spaghetti of conduits, no more limitations

*Mrs. Miller has been a guiding force in many local civic projects. She initiated and has been the horticultural advisor for Operation Triangle; she was horticultural consultant for the Seattle Freeway Park. The Fish Ladder planting discussed in this article is the latest of a series of horticultural projects for the Lake Washington Ship Canal for which she has been advisor over a period of 20 years. Her activities are not confined to the local scene: for seven years she has been chairman of the Environmental Horticulture Committee of the American Horticultural Society and is serving her fourth term as Horticulture Vice Chairman of The Garden Club of America.

on beautiful foliage growth because the plant's energy has been consumed by the roots' efforts to find nourishment, air and water under expanses of concrete. The tide will turn toward long-term plant survival.

Another transitional lesson is to be learned from earlier citizen interest in public planting, when the introduction of a green scene was enthusiastically received. Construction followed quickly before specific details were determined regarding the choice of plant material, costs of site preparation as dictated by existing site conditions, and source of maintenance or maintenance budget. As a result, a few years later the taxpayer paid unknowingly for replacements if the original planting was environmentally or horticulturally unsound. Often replacement led to a duplication of the original error representing a repetitious and costly setback—the kind of excessive municipal spending to which taxpayers object. The rapid strides made possible through an increased concern for this problem are illustrated by our freeway planting and other projects discussed below:

FREEWAY PLANTING

A specific example, and one which has often occurred during our nation's "pioneering" with freeway planting, concerns the initial planting design for the Interstate 5 embankments within the northern boundaries of metropolitan Seattle. Since the design consultant was from out of state, the Washington State Highway Department provided him with a list of Northwest native plants. The resulting schematic design called for the embankment facing west above Lake Union (a searing hot summer exposure) to be planted with *Cornus canadensis,* which is a cool-woodland forest plant. Concern caused by this problem and by similar fallacies in the design led to local consultation with our State Highway Commissioner. Full-sun tolerant, drought-resistant plants which were compatible with the design were recommended and found acceptable by both the Highway Department and the designer. This represents an accomplishment not only because the appropriate plant material was ultimately selected, but also because horticulturists and professional designers worked together successfully to find correct solutions to urban planting problems.

Following construction of the freeway planting, the busy small gardens bordering the freeway ramps were found not only to require very high maintenance but also to be little appreciated by motorists traveling at freeway speeds. Since then, these areas have been effectively simplified, reducing maintenance costs and providing a scale of planting which is discernible, so that plants can be appreciated by the motorist.

North of Seattle the use of pines is prevalent and successful to date. According to USDA, the majority of pines are susceptible to air pollution. However, probably because the freeway design has a snaking pattern, the prevailing southwest winds remove any high concentration of automobile exhaust fumes on the western bank and also carry it above the eastern bank. Whether in the future more intense pollution will adversely affect this area remains to be seen. As the planting continues farther north of the city limits, the use of more pollution-tolerant Douglas firs (which replace the pines in the design) assures greater success of the plantings.

Negative evidence for the use of pines is illustrated by the specimens located in the trough at the western end of the Evergreen Point Bridge. Individual differences in the condition of these specimens can perhaps be related to changes in microclimate and varying degrees of environmental stress within this area.

(Another example of unsuccessful use of pines is on the corner of Sixth Avenue and Spring Street, where trees are planted at street level against a concrete wall. The wall seems to create a stagnant pocket of air, trapping the exhaust emissions present at this busy intersection where full sun exposure also present probably creates high ozone levels [see previous issue, p. 2].)

FISH LADDER PLANTING

For all too common reasons of insufficient budgets, inadequate site analysis or a failure to address the issue of environmental horticulture, proper horticultural procedures are not always followed by public or private agencies. Unless specifications are firmly detailed in construction contracts and backed up by qualified construction inspection, most plantings will not be properly installed. A good example is the recent planting on the southern embankment of Salmon Bay adjacent to the U.S. Corps of Engineers' fish ladder at the H.M. Chittenden Locks. During the planning stages of the project, horticultural

Seattle Freeway Park—plazas and greenery in the city. Photo: G. Pirzio-Biroli

recommendations were accepted for this site, a steep bank with full sun exposure and a difficult soil situation of hard blue clay possessing extremely poor drainage characteristics and allowing virtually no root penetration. The horticultural recommendations called for the planting sites to be doubly large to provide ample planting soil with at least one foot of drainage rock beneath two feet of soil. The latter was to be retained on a horizontal level with wood headers jutting out from the bank to prevent the soil from sloughing down the embankment.

After construction was complete, an on-site inspection revealed that none of these requisites had been accomplished. No funds had been allocated to implement the recommendations. As a result, standard planting details were followed on a unique and difficult site; the plants had been set in inadequate holes in an embankment of blue clay with no means of retaining the planting soil and no provisions for drainage.

In preference to costly replacement, a challenging corrective effort was undertaken. Three-foot deep holes filled with drainage rock were added on both sides of the original plant pits, and boards were staked in place, projecting from the embankment to hold additional soil, provide a level area for rain absorption and prevent afternoon sun from burning the root surfaces. In time, the ground covers planted on the embankment will conceal this unsightly patchwork, and in the meantime the plants are faring well (see previous issue, p. 4).

SEATTLE FREEWAY PARK[1]

An excellent example of proper procedures can be found by studying the methods employed to create Seattle Freeway Park. This new urban park bridges Interstate 5, covers both public and private parking structures and is integrated with the plazas and terraces of a high-rise office building. No more unfavorable environment for growing plants can be found in Seattle. Yet because of enlightened planning and financing, eight years of close team work between city, state, county and federal governments and private citizens, and the brilliant design leadership of Lawrence Halprin and Associates, the lushly planted park is a real and lasting part of the lives of the people of Seattle.

Halprin, his project designer Angela Danadjieva and longtime associate Jean Walton, landscape architect and horticulturist, led the design team. The structural components of the garage, bridge and plaza had to be designed to meet the load requirements of the park elements. This meant that early in the design process, soil depth requirements for plants and location had to be determined. Understanding the unique environmental and social conditions of the site was a first priority. To assist in this effort, the firm of Edward MacLeod & Associates, Landscape Architects and Land Planners in Seattle, and their horticultural consultant, Betty Miller, were added to the team.

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[1]Referred to in previous article as Freeway Lid Park.

The criteria for plant material selection were based primarily on pollution and environmental tolerance qualifications including the ability to withstand strong winds, intense glare from concrete and glass reflection, and high ozone levels. But these were not the only tests the plants had to meet. In order to allow for shallower soil depth, thus reducing the structural requirements, it was critically important to select plant material that could flourish without requiring deep root systems. One of the guiding concepts of the design became the interplay of contrasting elements; the plant material was to play an important role as a contrast to the hard angular concrete. This meant that any plant included on the list had to have the proven ability to achieve reasonable size and lushness considering the environmental conditions that would necessarily limit its performance. Finally the plant list had to be diverse enough to accommodate the various microclimates present within the park while providing a harmonious and well-integrated planting.

Exposure and air pollution were the most important environmental conditions that influenced the planting concept. Plants were selected which would provide future windbreaks and needed shade. The planting plan was organized with dense edges of conifers, medium shrubs and finally smaller flowering shrubs at the edges of walks and open lawn areas. As these masses develop in size, the habitat will become suitable for more tender varieties of plants.

Ten lanes of traffic carrying 133,000 cars a day are bridged over by the park. The concrete lid creates a tunnel where plantings at both ends are subject to high concentrations of exhaust fumes. These end and expressway level plantings are depressed into the sunken freeway creating a lack of air circulation which tends to concentrate pollutants even further. Pines in this area already seem to be suffering from high ozone levels. Other plants such as Douglas fir and *Cedrus deodara* are standing up well. Because of the prevailing southwest winds, the northeastern section (East Plaza) should not be adversely affected by the exhaust fumes from traffic below. However, it is not yet known whether those same southwest winds will ultimately bring a detrimental dose to the southwestern section, either from the traffic or the industrial area to the south.

A third environmental factor requiring consideration was the depth and type of soil conditions to be created. The soil depth varies from 12 inches in turf areas to 72 inches in tree pits. Because the design of the park was considered when the bridge and parking structures were being designed, it was possible to increase the strength of the supporting structures in the areas where deepest soils were required. Necessary depths for trees were achieved through mounding, stairstepping of concrete planters, berming at the edges of the park and provision of tree pits or concrete boxes recessed into the structural slab. Walkways were constructed over a layer of sand rather than directly on top of the structural slab. This prevents each walk from becoming a barrier to root systems and drainage.

The soils were drained throughout the site by an underground web of perforated drain lines including individual drains for each sunken pit. Twenty thousand cubic yards of topsoil and sand were required. A mixture of two-thirds fine sand and one-third peat moss plus additional fertilizers made up the imported topsoil, and it was strictly specified and controlled in order to be lightweight and high in water retention, with good drainage characteristics. This mix, coupled with an automatic irrigation system which injects fertilizer directly into the water, provides a growing medium suitable for a wide variety of plants.

Quality control during construction was maintained with constant observation of the construction process. Plant material was inspected at the growing site, after shipment to the project site and again during and after installation. Soil mixtures were tested as each new batch arrived, and more than once the entire batch was rejected and removed from the site. The one occasion when inspection was lax resulted in the installation of a

***Mahonia aquifolium* 'Compacta' with a ground cover of *Waldsteinia ternata*.**

Photo: G. Pirzio-Biroli

Sumac silhouetted against a skyscraper, Seattle Freeway Park. Photo: G. Pirzio-Biroli

number of improperly dug and handled Douglas firs. The predictable outcome was the loss of nearly all of them just before the July 4, 1976 dedication ceremony. They were substituted with *Pinus sylvestris* and *Cedrus deodara*. Should the pines fall victim to pollution, they will be replaced with firs as originally planned.

We have sometimes been asked what design changes we would make with the benefit of hindsight. It has become apparent that the popularity of open air concerts and performances was underestimated. In the desire to provide a balanced mix of open space and planted areas, the crowds which gather for a concert are not entirely accommodated. The concentration of people attending an event has caused a number of plants to be inadvertantly damaged. Protection in the form of benches or raised planting beds, as occur in other areas of the park, could direct the movements of the occasional large crowd and protect these vulnerable areas without resorting to a greater percentage of pavement.

The colonization of bulbs in drifts and the more extensive use of perennials similarly planted in drifts would provide a more natural effect than the more costly formal use of annuals. Nakaharai hybrid azaleas (*Rhododendron nakaharai* hybrids) were used in ground cover beds where their prostrate form cannot be appreciated because of invasiveness of larger companion plants. The hybrid *Cotoneaster* 'Lowfast' is a suitable background plant for a steep bank, but it can become an unsightly tangle with maturity in the areas where it is planted; it could well be replaced with *Sorbus reducta*, which has a stronger and more orderly growth habit. A spectacular blaze of fall color could be introduced with the use of *Fothergilla major (monticola)*, whose scale is proportionate to such a massive structure. Both of these plants may soon be available. Other potential additions would be specimens of *Amelanchier laevis* for sheer beauty of flower in spring and its fall leaf color. Evergreen oaks such as *Quercus ilex* or *Q. phellos,* which have high environmental tolerance, would relieve the monotonous yellow-green spring color which dominates the planting during that season. The limitation on the use of evergreen oaks is that they resent fertilizing and watering and should not be planted in lawn areas. The original concept of more Douglas firs is desirable still. As a final recommendation, *Hedera helix*, now planted in beds where it will eventually become a problem (see previous issue, p. 8), should be replaced with the same maintenance-free ground covers already established elsewhere, for example, *Waldsteinia ternata, Cotoneaster* 'Soldam', et cetera.

The six-acre facility creates a totally new environment for this downtown area. Where obnoxious freeway noise once filled the air, a beautifully landscaped urban park now exists, filled with trees, shrubs, lawn, flowers, tranquil pools and cascading water—including a 32-foot waterfall that totally masks the noise of the freeway below.

Park visitors have been particularly impressed with the variety of bird species singing and chirping, "as happy as could be atop a busy freeway."

The concept of reclaiming through air rights valuable land previously dedicated solely to transportation, is one which has been successful in other cities and which could be utilized effectively in virtually every city in the country. Not only do the people of Seattle now have a handsome addition to their inner city, but a major

step has been taken to unite once more neighborhoods that had been cut off from each other by the freeway. If the designers achieve their ultimate goal, Freeway Park will be the catalyst for the creation of a large-scale system of landscaped plazas, walkways and terraces interconnecting many areas of Seattle over the freeway and streets down to the waterfront. Thus an extremely important statement about returning to a vital relationhip between people and the urban landscape will have been made.

OPERATION TRIANGLE

Operation Triangle was initiated in 1965 by a group of volunteers to promote the landscaping of 700 unsightly triangles created by Seattle's new freeway exits, entrances and other thoroughfares. A horticultural advisory committee endeavored to apply environmental stress criteria in the selection of material for each triangle since no two are environmentally alike. Since many of our planting projects have been dealt a severe blow when the maintenance costs have exceeded the available funds, Operation Triangle was intended to be a minimum-maintenance demonstration project as well.

Among the successes is a triangle in the Ravenna neighborhood. This has a southwest exposure on a hillside providing wind protection for the hemlocks (*Tsuga canadensis*) which cannot stand alone in a strong wind exposure, *Raphiolepis ovata* which can withstand low temperatures if protected from dehydration by wind, and *Oxydendrum arboreum*. In three years this 8000 square foot triangle reached a maintenance need of only two days a year for clean up of debris and a semi-annual replacement of mulch. In other words, it is now succeeding on its own with no spraying, fertilizing of watering. It is attractive with year-round color and interest.

Another site with the same desirable, nearly maintenance-free status is a larger transit stop triangle at the base of a hill facing east with afternoon shade and naturally moist soil conditions. It is planted simply with *Cornus florida* and salal (*Gaultheria shallon*). The choice of material was determined by the existing conditions including a low level of pollution at the site.

A twin triangle at the top of Columbia Street facing west is probably a good example of the effects of ozone. Salal is used as the ground cover. The upper triangle is shaded in the late afternoon and the salal is lush, tolerating the pollution from the exhaust gases. The salal on the lower triangle is exposed to full afternoon sun; most of the plants are barely surviving, and numerous replacements are required. Here one sees how other conditions present at each site may change the effects of pollution. It also explains why a list of pollution-tolerant plants does not stand alone for practical use, but is subject to the effects of other factors which may repeat or vary with every planting site and which must also be considered.

This Operation Triangle program is now in the capable hands of Marvin Black, City Arborist. He continues to use these small areas as pilot projects to test our environmental stress problems, carrying out the original intention of the program. It is anticipated that a number of potentially urban-tolerant species will be tested in the near future. Our Northwest native fern, *Woodwardia fimbriata,* deserves a trial on one of these triangles. The plant, which is evergreen with a strong, handsome pattern, to three feet with a four- to five-foot spread, requires filtered shade. Our native sword fern, *Polystichum munitum*, is

A triangle near Ravenna Ave. N.E., with hemlocks and *Raphiolepis* growing densely in the sun.

Photo: G. Pirzio-Biroli

unpopular because of the untidy appearance of its year-old fronds. Other large-growing varieties of polystichum should be given trial, for instance *P. setiferum viviparum* and *P. acrostichoides* which can tolerate more sun.

Some of the mature handsome species we see today are listed as pollution susceptible yet are still doing very well. This is because they had more favorable growing conditions as young trees prior to our current environmental pressures. The question is how much longer will presently healthy plants survive with increasing environmental pressure, and for how long will escalating costs permit us to continue the establishment of new planting.

The most effective weapon has proven to be the emphasis placed wisely on proper research, planning, greater investment in site preparation and long-term maintenance. The future availability of both plants and planting funds depends on a concentrated effort in a program designed to provide plant survival rather than replacement.

ACKNOWLEDGEMENT

Edward MacLeod (City of Seattle landscape architectural consultant for Halprin and Associates, landscape architecture firm in San Francisco) assisted with the coverage on the Freeway Park in this article.

Book Review

Books reviewed in the Arboretum Bulletin *are usually available for use at the Arboretum library. Readers are reminded that books may be purchased with a 10 percent discount through the Arboretum Foundation Book Committee (Loretta Slater [206] 232-0456).*

TREE ECOLOGY AND PRESERVATION, by A. Bernatzky. Elsevier Scientific Publishing Company, Amsterdam, The Netherlands, 1978. 357 pages. Price: approximately $70.

The concern for environmental preservation and specifically tree ecology certainly is not reserved to the United States, as is shown by this fine publication written by a German author and translated into English. The reader is reminded throughout the book, by the extensive references, that much can be learned from the exchange of knowledge researched around the world. It is to be hoped that this European text on tree ecology is just the beginning of many translations distributed between cultures, sharing solutions to common problems.

The basics of plant morphology, anatomy, physiology and ecology are reviewed in the opening chapters with the author quickly moving into trees in their natural and urban environments. This interesting comparison between "rural" and "town" trees focuses on such economics as radiation, heat, water, carbon and soil. Possibly the most timely section deals with vegetation and its contribution to our urban settings. This has great value to us in the Northwest, for as we continue to grow and expand we are having to deal more and more with those ills plaguing large urban centers. Reduction of temperature, noise abatement, control of particulate and gaseous pollution, oxygen production and the advantages of shelter belts are a few of the subjects detailed by the author as contributions of trees in cities. Practical information on trees useful in urban plantings is nicely summarized in tables on noise reduction, et cetera. The first half of the book concludes with a sidelight on the effects of trees on physical and mental health.

Specific techniques for tree preservation occupy the second half of the text with a multitude of figures and drawings relating the methods involved. Here the author's vast personal field experience is reflected in his treatment of cabling, bracing, cavity treatment, tree nutrition, planting and construction protection of plantings. The basics of false-color infrared photography to determine the condition of trees and the control of pests and diseases are final highlights.

Clearly this publication has a potential wide-ranging readership with its stress on the scientific and practical. Aimed at the layman as well as the professional, it would be a valuable tool for those interested in urban plantings and their contributions.

JIM WALKER
Glen Hunt and Associates

Special Programs

A HORTICULTURAL AF-FAIR

The Arboretum Foundation, in cooperation with the Agricultural and Natural Resources Education Department of the Superintendent of Public Instruction, is presenting the first (of what we hope will be many) Horticultural Af-Fair, scheduled for Thursday, May 10 from 9 a.m. to 4:30 p.m.

Approximately 130 vocational-agriculture and horticulture students representing 15 to 20 high schools in King, Snohomish and Pierce counties will attend lectures at the U. of W. HUB (transportation will be arranged), followed by an afternoon program of lectures and tours at the Arboretum. Within an open-question atmosphere, students will be introduced to a variety of subjects and career opportunities.

Chairman of the planning committee is Glen Hunt, assisted by: Mr. John Putnam, the Mesdames Fred Czerniski, George Frazier, Daniel Coleman and Allen Moses from the Arboretum Foundation and Mr. Joseph Witt of the Arboretum staff. Also assisting are high school instructors: Shane Dunbar, Mariner High; Tony Angell, Shoreline; Larry Fulner, Nathan Hale; Jack MacDonald, Lincoln; and Norm Gomness, Interlake.

LECTURE ON TOPIARY

The Northwest Ornamental Horticultural Society (N.O.H.S.) will sponsor a third in its series of lectures, *Shaping Your Gardens,* on April 19 at 8 p.m. in the Museum of History and Industry. The title is "Topiary: A Fascinating Specialty." The lecturer is Sally Reath of Philadelphia, an expert on the subject. Remember, this is an evening lecture.

SPRING PLANT SALES IN THE SEATTLE AREA

Children's Orthopedic Hospital Plant Sale, University Village; Wednesday, April 18, 9 a.m. to 4 p.m., and Thursday, April 19, 9 a.m. to 1 p.m.

Arboretum Foundation Plant Sale, May 2 & 3 (See p. 31 for details).

N.O.H.S. Fern Sale, Bellevue Square Pavilion; Thursday & Friday, June 14 & 15, 10 a.m. to 6 p.m., and Saturday, June 16, 10 a.m. to 1 p.m.

THE POLITICS OF TREES—PART II

A second all-day symposium on this important topic will take place on Friday, May 18 in the HUB on the University of Washington Campus. Of interest to readers of Mrs. Miller's articles on environmental horticulture is the fact that she was a featured speaker in Part I, which was held on January 26 (*Arboretum Bulletin* 41[4]:9).

AN EXHIBITION OF BOTANICAL ART AT THE UNIVERSITY OF BRITISH COLUMBIA

The Botanical Garden of U.B.C. with the aid of the Friends of the Garden is sponsoring an exhibition, *Plantae Occidentalis*. This project has been developed over the past two years and represents an extension of the Botanical Garden theme, 'Plants and Man,' specifically the interpretation of plants through art.

The exhibit will remain at the Museum of Anthropology, the University of British Columbia, from April 17 to June 15, 1979. It will then travel to other museums throughout Canada.

Notes and Comments

The *Bulletin's* editorial assistant, Mary Ann Schnaidt, resigned at the end of 1978 to spend more time with her family and in her garden. Mary Ann was with us for only six months, but she proved to be a very intelligent assistant with an excellent grasp of the English language. Her replacement is Sue Kyte, who was graduated with multiple honors from the School of Communications at the University of Washington. Although we shall miss Mary Ann very much, we welcome Sue whom we have already found to be capable and enthusiastic.

The Arboretum Foundation's Kelly Nishitani Unit, in a magnificent gesture, has transferred some $3000 to the Prentice Bloedel, Japanese Garden Unit 73, to be used for maintenance and repairs in the Japanese Garden. First use planned for these funds is the repair and replacement of electric wiring and pole lamps, partially destroyed by vandals.

About one half of the parking lot between the office and the greenhouse is being used by a contractor for METRO as a base for a sewer rehabilitation project. This work is expected to continue through March or slightly later. The contractor has assured us they will be gone before the plant sale in early May.

Announcements from the Unit Council

The Arboretum Unit Council will hold its Second Annual Horticultural Exhibit in the McCurdy Room of the Museum of History and Industry, 2161 E. Hamlin Street, Seattle on Thursday, March 29 from 1 to 8 p.m., and Friday, March 30 from 10 a.m. to 3 p.m. It will be free and open to the public.

The exhibit will feature early spring blossoming plant materials currently growing in the Puget Sound area gardens of unit members. Each participating unit will have a table to display its members' entries. Although it is primarily a Unit Council project, there will be a table as well for Foundation members who are not associated with units. The tables in the show will be judged by an award selection committee, which will present ribbons for the units' tables deemed Most Educational, Best Groomed, Containing Most Unusual Plant Material, and Most Artistically Displayed. In spite of the unusually cold winter, a wide variety of blossoms and foliage is expected, including bulbs, perennials, trees, as well as bonsai and house plants. Books on gardening and related subjects will be for sale. Light refreshments will be served. Ruby Williams is show chairman.

The spring session of the Botany class will begin on March 26 and continue for 10 Mondays through May, from 10:30 to 12:30 p.m. in Johnson Hall on the U. of W. campus. A.B. and Virginia Adams will be the instructors. Emphasis will be on native spring flora and there will be several field trips. The cost is $25. Reservations may be made by calling the Arboretum Foundation office (325-4510).

Work and Fun Day will be Thursday, April 12, when unit members and Arboretum supporters join in a Spring Clean-Up of the Arboretum. Volunteers will meet at the offices at 9:30 a.m., armed with tools, boxes and brown bag lunches. There will be the traditional contest for the most original hat, the longest weed and other unusual objects found while working. Held rain or shine, Work and Fun Day provides an opportunity to contribute personal effort in support of the Arboretum. This year's chairman is Mary Ann Trombold.

Jeanne Gardiner, Bulb Sale Chairman, reports the final profit of the 1978 sale was $6610.

Information regarding the Arboretum Foundation Plant Sale may be found on the opposite page.

PAT MONCINI

Swainson's Thrush on a *Pyracantha*. Photo: Roger and Joy Spurr

THE 1979 ARBORETUM FOUNDATION PLANT SALE

will have two new tables this year:

Birds, Bees and Butterflies
(or how to attract them
to your garden)

A Fern Grotto in charge of
fern expert, Judith Jones

The sale will continue to feature the new and unusual, top quality plants and garden-related materials for which it has become renowned.

For Pre-Orders call:
Pat Bender
4123 N.E. 186th
Seattle, Wa. 98155
Cut-off Date: April 15

For donations call:
Ted & Evelyn Rathje
283-3692

If you want to work
on the sale, call:
P.S. Chairman
Suzanne Wilson
822-5370

ARBORETUM PARKING LOT

Wednesday, May 2, from 4 to 8 p.m.

Thursday, May 3, from 10 a.m. to 4 p.m.

University of Washington Classes

The *Bulletin* will be published this spring some weeks after *Spectrum,* the quarterly journal for Continuing Education, has been sent out. For that reason, some of the courses described below may already have been filled. We urge those of you who are interested in obtaining advance information to place your name on the mailing list for *Spectrum* by calling 543-2590.

Continuing Education

SCIENTIFIC DRAWING. Instructor: Phyllis Wood, scientific illustrator, Health Sciences Illustration. Mondays, April 2 - June 11; 7-10 p.m. 10 sessions, $40.

PLANT PROPAGATION. Care and treatment of seeds, seedlings and bulbs. Instructor: Diane Varney, M.S., Botany. Mondays, April 2 - June 4; 1:30-3:30 p.m. 9 sessions including one field trip, $35 (materials included); taught on campus in the U. of W. greenhouse.

IDENTIFYING MOSSES AND LIVERWORTS OF THE PACIFIC NORTHWEST. No scientific background necessary. Instructor: Elva Lawton, Asst. Curator, Herbarium. Tuesdays, April 3 - June 5; 7-9:30 p.m. 10 sessions plus 2 field trips (arrange own transportation); $45.

PEOPLES OF THE MOUNTAIN WILDERNESS. Includes examination of the Balti people of K-2 and Nanga Parbat in the Himalayas. Instructors: Richard Emerson, Professor, Sociology, and Pat Emerson, specialist in South Asian Studies. Tuesdays, April 3 - May 22; 7:30-9:30 p.m. 8 sessions, $25.

BIRDS IN THE FOREST ENVIRONMENT — A WEEKEND AT PACK FOREST. Includes bird identification, habitat, calls and the effects of forest conditions on bird populations; bring binoculars. Instructors: David Manuwal, Assoc. Professor, Wildlife Science, and Chadwick Oliver, Asst. Professor, Forest Ecology, College of Forest Resources. Saturday, 9 a.m. to Sunday 4 p.m., June 9 - 10; Pack Demonstration Forest, Eatonville; $57 (includes all meals, dormitory lodging, linens and field-trip transportation). No refunds after June 1.

IDENTIFYING PLANTS OF THE PACIFIC NORTHWEST. A laboratory course requiring no scientific background. Instructor: Arthur Kruckeberg, Professor, Botany. Text: *Flora of the Pacific Northwest,* 2nd ed., Hitchcock and Cronquist (bring to first class). Tuesdays, April 3 - May 22; 7-10 p.m. 8 sessions plus one weekend field trip (arrange own transportation); $45.

To register, call the Office of Continuing Education, 543-2590.

Arboretum Courses

SPRING TOURS. Tours of the arboretum grounds in spring bloom. Instructor: Joseph Witt. Class limited to 20; meet at Arboretum office. Saturdays, April 14 & 28, May 12 & 26; 10-12 noon. 4 sessions, $10.

PROPAGATION OF SOFTWOOD CUTTINGS. Instructor: Richard van Klaveren, Arboretum propagator, will teach techniques for propagating woody plants. Materials and plants furnished. Arboretum greenhouse; class limited to 15. Saturdays, June 2 & 9; 9:30-12 noon. 2 sessions, $12.

BASIC GARDEN MAINTENANCE. Basic gardening techniques including soil preparation, planting, fertilizing, mulching, pruning and seasonal care of plants. Instructor: Chico Narro. Class limited to 15; Arboretum greenhouse. Saturdays, April 7-May 12; 1-3 p.m. 6 sessions, $15.

IDENTIFICATION OF NATIVE TREES AND SHRUBS. Field class covering 40 species of common trees and shrubs native to western Washington. Instructor: Carla Culver. Class limited to 20; meet at Arboretum office. Saturdays, April 21-May 19; 2-4 p.m. 5 sessions, $12.

BIRD IDENTIFICATION FOR BEGINNERS. Instructor: Merilyn Hatheway, experienced birder, will conduct a field class on land birds commonly found in the Arboretum and waterfowl on Lake Washington. Binoculars required; appropriate clothing and boots recommended. Class limited to 15; meet at Arboretum office. Saturdays, March 17 & 31, April 7, 21 & 28, May 5; 9-11 a.m. 6 sessions, $15.

For further information on Arboretum courses, call 543-2730.

Pacific Science Center Classes

MOUNTAIN WILDFLOWER WALKS. Instructor: Perry Lovelace. Orientation: April 23, 10-noon. All day hikes in the Cascades: April 30, May 7-21. $25 (includes transportation).

SPRING MUSHROOM STALK. Instructor: Susan Libonati-Barnes. Class session on Morels: April 19, 7-9 p.m. Field trip (transportation by carpool): Saturday, April 21, 9 a.m.-5 p.m. $10.

NATURE PHOTOGRAPHY: RAINDROPS AND F-STOPS. Instructor: Rick Ells. March 27 & April 3-17, 7-9:30 p.m. Morning field trip April 7 at Discovery Park. $20.50

For information call 625-9333.

Weather in the Arboretum

The intense cold which gripped the Pacific Northwest in late December, 1978 and early January 1979 will give us the opportunity to assess the ability of a number of newer plant introductions to withstand severe cold. This arctic period was the coldest and most prolonged since 1972-73. There were five days when our maximum temperature did not rise above freezing and thirteen days when the minimum temperature was 32°F or below. Our lowest recorded temperature was 10°F on December 31, but a thermometer in the nursery read 7°F.

At this writing, it is too soon to make any serious inventory of what damage occurred to the collections, since we may well have another cold wave as bad or worse. However, a cursory examination made in mid-January indicates that only those plants usually injured or killed by such an event are showing damage. A further and more detailed report will be forthcoming.

J.A.W., January 23, 1979

The Arboretum welcomes information from local gardeners regarding the effects of this winter's cold weather. The name of the plant and a description of its location or special microclimate would be helpful.

Daphne blagayana **flowering in the Mulligans' garden in April. Photo: Brian O. Mulligan**

Errata

We wish that we could say that most of our errors, apart from "typos," were made on purpose. However, we must own up to misunderstanding and/or carelessness in the following instances.

1. We did not intend to duplicate the last four paragraphs of Brian Mulligan's article on his and Margaret's garden, Part I (41:3), in the second part (41:4). We very much regret this duplication because we might otherwise have used more photographs.

A confusing typographical error appeared in a caption of that second part. On page 31, the rose is the cultivar 'Fantin Latour.'

2. We erred in omitting the phrase, "in the greenhouse," from a sentence on page 4 (41:4). It should read, "Planners should avoid nursery stock which has been held overly long in the greenhouse in an effort..."

3. In the book review of *The Wilderness World of John Muir* (Vol. 41, No. 3, p. 36), a phrase in the first paragraph of the second column should read, "...warms like a fire..." (not "fir"!).

New Members of the Arboretum Foundation

We are pleased to welcome the following new members (September 1, 1978 through November 30, 1978):

Annual—Abundant Life Seed Foundation, Mrs. Roy W. Anderson, Mrs. J. Anthony Angell, Mrs. J.W. Bailey, Mrs. Helen S. Barton, Mrs. Sheila Berg, Kathy Carlisle, Mrs. Rachael Colby, Nancy Cram, Ned G. Crooke, Mrs. Frank Cunningham, Mrs. Frank H. Ernest, Miss Marguerite Field, Robert B. Griffith, Mrs. Paul L. Hansen, Mrs. Steven Hepp, Mrs. Emily Heskin, Mrs. O.J. Humphrey, Jr., Hurstwood Garden Club, Mrs. D.R. Johnson, Mrs. Elizabeth Johnson, Mrs. Velma Johnston, Mrs. Stephen Kelly, Mrs. W.B. Kimball, Mrs. Grace B. Kipp, Anne E. Kowalishen, Mrs. Wm. F. Kraus, Lake Washington Garden Club #2, Mrs. Richard Lea, Mrs. Michael Legge, Le Jardiniers Garden Club, Mrs. Wm. Le Mire, Mrs. James Masterson, Mrs. Florence Miori, Mrs. W.J.B. Morelock, Mrs. Charlotte Moser, Frank Mossman, Mrs. Martha Moulton, Mrs. Gordon Munro, Mrs. Clarence Olson, Mrs. Keith Patrick, Mrs. Debbie Peterson, Mrs. Nancy Phillips, Mrs. Ralph Purvis, James E. Raisis, Nancy Reed, Mrs. A.N. Rettenmier, Mrs. John Riley, Miss Jean Russell, Mrs. Merle Sauer, Mrs. Grace G. Schettler, Charlotte H. Simpers, Mrs. Rena Smilkstein, Mrs. Donna Smith, Mrs. Linda Swanson, Mrs. Ethel Thomsen, Diane Tjomsland, Mrs. John Udd, University of Colorado-Denver, John Vandree, Burt Wallace, Laila L. Walmsley, Mrs. Lois M. Watson, Lenora Wegner, Mr. and Mrs. Victor Westerhausen, Rebecca Wiess, Mrs. R.G. Williams, Mrs. Allan G. Wing, Mrs. Joseph G. Winston, Mrs. John F. Wolcott, William E. Wrede, Mrs. Eugene Wright, Mrs. Robert G. Wright, Philip A. Young, Mrs. Robert E. Zahler, Mrs. Carol ZumBrunnen, Mrs. Lynne Zweizig.

We are also grateful to the following who have increased their dues to: *Life*—Mr. and Mrs. John Putnam. *Sustaining*—Robert H. Kizer, Walter Kupersmith.

CALENDAR OF EVENTS

Arboretum Foundation:		Regularly Scheduled:	
Board of Directors	March 8	Greenhouse Day	Every Tuesday
Executive Committee	April 12	The Mae Granston	
	May 10	Rhododendron Study Group	1st Monday
Annual Membership Dinner	June 7	Herbarium Committee	1st Friday
		Northwest Natives	
Unit Council:		Study Group	3rd Monday
Unit Council Meeting	May 17	Rock Garden	
Governing Board	April 19	Study Group	3rd Wednesday
	June 7	Arboretum Explorers	4th Wednesday

Unit Council Horticultural Exhibit, March 29 & 30.
Museum of History and Industry (see page 30).

Work and Fun Day, April 12 (see page 30).

Children's Orthopedic Hospital Plant Sale
April 18 & 19 (see page 29).

N.O.H.S. program on Topiary, April 19, 8 p.m.
Museum of History and Industry (see page 29).

1979 Arboretum Foundation Plant Sale, May 2 & 3.
Arboretum Parking Lot (see page 31).

29th Annual Rhododendron Show, May 4-6.
Bellevue Square Pavilion (see page 39).

Horticultural Af-Fair, May 10, 9 a.m.-4:30 p.m.
U. of W. HUB and Arboretum (see page 29).

N.O.H.S. Fern Sale, June 14-16
Bellevue Square Pavilion (see page 29).

FOR ADDITIONAL INFORMATION, CALL 325-4510

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†indicates plants in Brian and Margaret Mulligan's garden
‡in issue 3 indicates Marvin Black's article on Seattle street trees
‡in issue 4 indicates Mrs. Pendleton Miller's article on environmentally tolerant plants

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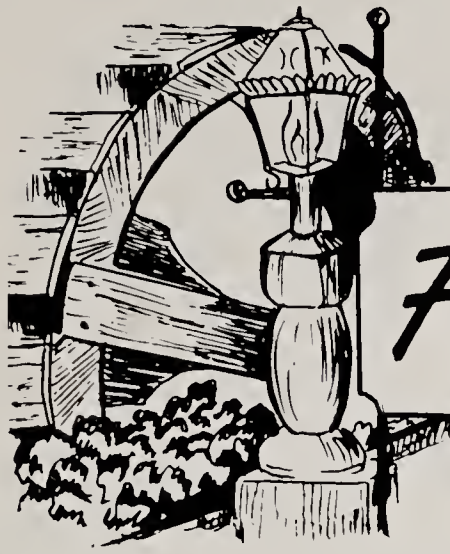

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